BOOK OF ABSTRACTS

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Plenary and Keynote Talks

Albert Einstein: a biography through The New York Times

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This talk aims to presents a unique portrait of the famous physicist Albert Einstein entirely based on clippings of a great New-York newspaper: The New York Times. The approach used in this presentation consists in collecting daily press clippings to make of history may, in some way, be compared to the Pop Art movement collecting everyday objects to make of artworks. That's the reason why we called Pop History. Thus, the impressive number of articles about his life and his works offers a new viewpoint of this character. It allows rebuilding, on one hand, almost day to day, the most significant events of his life and, on the other hand, it enables to highlight some of its most intimate traits that appear in the interviews he had granted to this newspaper. It also provides a popularized presentation, devoid of any mathematical development, of his scientific theories (Special and General Relativity, Gravitational Waves and Unified Field Theory) which become thus accessible to the layman. At last, through many unusual and funny anecdotes contained in some unknown articles an unexpected portrait of Einstein is disclosed.

Highly organized behaviour induced by noise in nonlinear networks and its control

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The brain is a network of coupled neurons, each experiencing an input that reminds a random process and demonstrating irregular spiking. Synchronization between the spiking neurons is usually associated with

epilepsy and Parkinsonian disease. Models of neural networks have been the subject of extensive research as part of the quest to understand the brain function. A minimal-size network of only two stochastic interacting neurons can demonstrate synchronization, while both units continue to spike stochastically. Application of delayed feedback control can modify some features of their collective behavior, such as slight alteration of the time scale and changing the amount of coherence, but their dynamics remains random. On the contrary, for a large network of neuron-like stochastic elements it has been earlier shown that all-to-all coupling can give rise to highly ordered behavior of the mean field from periodic to chaotic one. The same phenomenon can be interpreted from another angle, namely, as constructing a large network of interconnected silent neurons, and then applying independent random noises to each unit and thus inducing a deterministically looking behavior of the macroscopic mean field of the whole structure. This phenomenon can be described analytically with some limitations. It appears that chaotic oscillations that emerge from a large number of sources of noise applied to a highly nonlinear large complex system respond to the delayed feedback in almost the same manner as classical chaotic oscillations existing in systems without any noise sources. Thus, from the response to external perturbations it is hard, if possible at all, to distinguish between chaos born via a classical scenario in a fully deterministic system and chaos born out of noise in a highly complex large network.

Plasma hysteresis and instability: A memory perspective

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This paper presents a historical review of the Duddell 'Singing-arc' and its technological development into the triode vacuum tube that include the controlled of both hysteresis and stability. Oscillograph Lissajuos figure measurements (in I-V plane, Q-V plane and harmonic plane) of these deleterious effects are compared to hysteresis and stability issues in modern low-pressure parallel-plate systems and atmospheric pressure plasma system. In doing so, attention is given to the use of the original oscillograph measurement and todays analog, digital and software methods of measurement. Using both the original and contemporary measurement this paper comments upon the volatile memory subclass of the generalised definition of memristor, and whether the 'Signing arc' was one of the earliest memristors.

Keywords: Singing-arc, plasma hysteresis, plasma instabilities, atmospheric pressure, Lissajuos figures, limit-cycles, self-oscillations.

Response and Fluctuations in Geophysical Fluid Dynamics

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The climate is a complex, chaotic, non-equilibrium system featuring a limited horizon of predictability, variability on a vast range of temporal and spatial scales, instabilities resulting into energy transformations, and mixing and dissipative processes resulting into entropy production. Despite great progresses, we still do not have a complete theory of climate dynamics able to encompass instabilities, equilibration processes, and response to changing parameters of the system. We will outline some possible applications of the response theory developed by Ruelle for non-equilibrium statistical mechanical systems, showing how it allows for setting on firm ground and on a coherent framework concepts like climate sensitivity, climate response, and climate tipping points. We will show results for comprehensive global climate models. The results are promising in terms of suggesting new ways for approaching the problem of climate change prediction and for using more efficiently the enormous amounts of data produced by modeling groups around the world.

Ref: V. Lucarini, R. Blender, C. Herbert, F. Ragone, S. Pascale, J. Wouters, Mathematical and Physical Ideas for Climate Science, Reviews of Geophysics 52, 809-859 (2014)

Unveiling Complexities of Non-smooth Dynamics: Theory and Experiments

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In this lecture I will examine nature of subtle phenomena in non-smooth systems. I will start with linear oscillators undergoing impacts with secondary elastic supports, which have been studied experimentally and analytically for near-grazing conditions [1]. We discovered a narrow band of chaos close to the grazing condition and this phenomenon was observed experimentally for a range of system parameters. Through stability analysis, we argue that this abrupt onset to chaos is caused by a dangerous bifurcation in which two unstable period-3 orbits, created at "invisible" grazing collide [2].

The experimentally observed bifurcations are explained theoretically using mapping solutions between locally smooth subspaces. Smooth as well as non-smooth bifurcations are observed, and the resulting bifurcations are often as an interplay between them. In order to understand the observed bifurcation scenarios, a global analysis has been undertaken to investigate the influence of stable and unstable orbits which are born in distant bifurcations but become important at the near-grazing conditions [3]. A good degree of correspondence between the experiment and theory fully justifies the adopted modelling approach. Similar phenomena were observed for a rotor system with bearing clearances, which was analysed numerically [4] and experimentally [5]. To gain further insight into the system dynamics we have used a path following method to unveil complex bifurcation structures often featuring dangerous co-existing attractors.

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Invited and Contributed Talks

Determination of cell wall properties using a micro-mechanical compression model of apple tissue

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The mechanical properties of fruit tissue determine quality attributes such as firmness, and susceptibility to mechanical damage. Fruit tissue is a heterogeneous material, composed of a microscopic cell wall network under tension by turgid cells. Up to 30% of the tissue volume is occupied by intercellular air spaces. Using the models of histology of apple tissue, compression experiments were performed in silico using a micro-mechanical model to compute the non-linear deformation properties of the tissue. The models were compared with experimental data from actual compression experiments and with modeling results from literature. Young’s modulus of cell walls was estimated by fitting simulated stress-strain curves to experimental curves of apple tissue. Values were estimated to be 39 3 MPa and 31 5 MPa for Braeburn apple and Jonagold apple, respectively. Stress-strain curves were obtained with coefficients of accuracy (R2) greater than 90%. The effect of different parameters (turgor pressure, cell size, cell wall stiffness, porosity) on the compressibility of the tissue was also simulated. Compression resistance increases with increasing turgor pressure and Young’s modulus of the cell wall, and decreasing cell size and porosity.
Keywords: micromechanical properties, Stress-strain, virtual tissue generator, mathematical modeling, postharvest

Pairs of Vortex-Antivortex and Higgs Boson in a Fractal Quantum System

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The stochastic deformation and stress fields inside the fractal multilayer system with active nanoelements are investigated. It is shown that in a coupled system (fractal layer – fractal quantum dot) a decrease of semi-axes of the quantum dot leads to a decrease of the amplitude and the

appearance of "influx" from the main peak. With increasing the semi-axes a broadened peak is formed on the background of the stochastic base (signal in the form of halo type). As the active nanoelement a set of ultracold 23Na atoms in an optical trap is selected. It is shown that some of the physical properties (speed, quantization of the flow; hysteresis) of excitations such as a pair of vortex-antivortex associated with the influence on their Bose-Einstein condensate a superfluid (where excitation is the Higgs boson). The analysis of the experiment and the relations with the black hole model is carried out for the ring-shaped trap.
Keywords: Fractal quantum nanosystem, Stochastic deformation and stress fields, Optical trap, Ultracold atoms, Pairs of vortex-antivortex, Higgs boson.

Attractors and Deformation Field in the Coupled Fractal Multilayer Nanosystem

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The behavior of the deformation field of coupled multilayer nanosystems: fractal nanotrap – fractal bulk structure is investigated. It is shown that when crossing the surface of the coupled structure critical planes formed a line of singular points (attractors) of the deformation field. Analysis of the isolines of singular points core shows that the behavior of coupled systems with the same or different centers of gravity varies considerably. It is shown that the deformation field of coupled structures is determined by mutual influence of stochastic processes on each other. Such effect as the displacements of fractal structures, the transformation of a thin quasiperiodic structure inside the trap, the appearance of an extra thin structure outside the trap are possible when changing the parameters.
Keywords: Fractal Bulk Structure, Fractal Nanotraps, Coupled Systems, Attractors, Deformation Field, Multilayer Nanosystem.

Attractors in Natural Convection

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We studied numerically the transient laminar natural convection in two square cavities.The fluid is air and water.The horizontal walls are adiabatic and the vertical walls are composed of the two regions of the same size maintained at different temperatures. Transfer equations are resolved using the stream function -vorticity formulation. We analyzed the effect of Rayleigh number on heat transfer and on the roads to chaos

borrowed by the system for the two cavities .The first Hopf bifurcation was observed and our systems are determinist. As the Rayleigh increased multiplicity solutions are represented by attractors in spaces of phases. We calculated the fractal dimension for each attractor.We compared results obtained between of air and water which are in cavities
Keywords: Natural convection, Bifurcation, Critical Rayleigh number, Limit point, Limit cycle, Attractor, Fractal dimension.

Randomization of the Sharkovsky-type theorems

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Following our conclusions in articles [A1, A2, AB], we will formulate a universal randomization principle of deterministic results. On this basis, we will firstly introduce the randomized versions of classical theorems for single-valued interval and circle self-maps due to A. N. Sharkovsky, L. Block, et al. Then those of our deterministic theorems for multivalued maps will be presented. As a randomization effect, some new periods of forced orbits can occur. Finally, the related notion of a random chaos will be discussed.
Keywords: Sharkovsky-type results, randomization, coexistence of random orbits, forcing properies, interval and circle self-maps, multivalued maps, random chaos.
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Modelling the Brain: From Dynamical Complexity to Neural Synchronisation, Chimera-like States and Information Flow Capacity

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In this talk, I will present a review of my recent work on the study of the brain, aiming to reveal relations between neural synchronisation patterns

and information flow capacity, namely the largest amount of information per time unit that can be transmitted between the different parts of the brain networks considered. I will start with the working hypothesis, presented in Ref. [1] and supported by numerical evidence, that brains might evolve based on the principle of the maximisation of their internal information flow capacity. In this regard, we have found that synchronous behaviour and information flow capacity of the evolved networks reproduce well the same behaviours observed in the brain dynamical networks of the Caenorhabditis elegans (C.elegans) soil worm and humans. Then, I will talk about the verification of our hypothesis by showing that Hindmarsh-Rose (HR) neural networks evolved with coupling strengths that maximize the information flow capacity are those with the closest graph distance to the brain networks of C.elegans and humans. Finally, I will present results from a recently published paper [2] on spectacular neural synchronisation phenomenon observed in modular neural networks such as in the C.elegans brain network, called chimera-like states. I will show that, under some assumptions, neurons of different communities of the brain network of the C.elegans soil worm equipped with HR dynamics are able to synchronise with themselves whereas others, belonging to other communities, remain essentially desynchronised, a situation that changes dynamically in time.

Keywords: Brain modelling, Neural synchronisation, Chaotic behaviour, Information flow capacity, C.elegans, Hindmarsh-Rose neural dynamics, Chimera-like states.

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Surprising «quantum statistical» derivation of Landau damping. Discussion on simple models

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We elaborate on quite a surprising mapping between plasma excitation Landau damping to a « quantum statistical » perturbative treatment of Schrödinger equation in a nonlinear potential.

Firstly, the setting for this mapping is to assume spatially inhomogeneous stable modes, such as Bernstein Green Kruskal modes. Bulk plasma frequency is then locally slightly altered by those. From a low frequency approximation of Bohm and Gross dispersion relation, we write a nonlinear Schrödinger equation for fluctuating macroscopic quantities, like the density of trapped particles. Naïvely, a statistical (imaginary) time dependant perturbative treatment of the relaxation of excitations comes from self-scattering. Dyson's equation accounts for the renormalised bulk plasma frequency. This setting also predicts a Lamb shift for the only remaining ground state energy mode. Landau damping is retrieved when one estimates the energy spectrum from local equilibrium, which shows a condensation at Debye's wavelength. Or in other words, a gap has opened.

It is in full agreement with the fluctuation-dissipation theorem and holds for all time.

This mapping seems to be a natural continuum limit for a statistical treatment of bulk plasma perturbations. It can be extended to the non perturbative case of Lynden-Bell violent relaxation.

Secondly, we discuss the justification of renormalisation in this context. Naturally, the statistical treatment is traced back to the presence of intrinsic disorder from the wild oscillations in phase space. Precisely, a minimal mean field model is written for the coarse grained dynamics. It is instructive to draw an illustration from the idea of a hierarchy of KAM tori and the emergence of frustration for the oscillations of trapped particles. Based on ideas by D. Escande and S. McKay, we arrive at an effective coupling between neighbouring clusters of trapped particles which is renormalised chaotically. Thus, defining a local phase for the spatially inhomogeneous oscillations of macroscopic quantities, it is possible to « geometrize » their symplectic dynamics, thereby justifying the initially intuitive « quantum statistical » treatment of Schrödinger equation.

For driven systems, the chaotic parameter further forces large deviations on the dynamics, with non-Maxwellian stationary distributions, or strong turbulence. Therefore, since at large scales exchange entropy with bulk plasma and (KS-)entropy production rates are high, a comparison with coupled chaotic map lattices for coarse grained observables is qualitatively worthy. This implies a rich structure of phase space diagram, where many transitions are to be expected between stable or metastable states (phases), related to QSSs (quasi stationary states).

Keywords: Landau damping; Quantum statistical perturbation theory; Frustration; Renormalization; Chaotic map lattices

A Comparison between the most regular entropies employed to study bio-signals: Gait record study

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Estimation of the best fitted tool for analyzing real-world data which its contamination to noise is irresistibly inevitable makes the process of selecting the proper analyzing tool in a high level of importance. In addition, when working with non-deterministic data, filtering is highly rejected because of deterioration it brings to origin of the signal and the information it contains. Here, we examine and compare the best compatibility and robustness of four of the most commonly applied entropies in bio-signals analyzing to situations where noise exists and data is short in length. The chosen tools are: Kolmogorov-Sinai (K-S) Entropy, Approximate Entropy (ApEn), Sample Entropy (SamEn) and Detrend Fluctuation Analysis (DFA). We will to find the noise-adaptable information estimation tool out of these four that is more compatible with a mix system of semi-cyclic and chaotic function as gait represents. For this purpose, a group of patients with Osteoarthritis of right knee versus a control group are studied walking on a motorized treadmill at a constant pace of 1.1 m/s. Then, the original time series were divided to smaller subsignals and results were achieved for both smaller and the original signals in order to be compared in size and trace the system's behavior. The results showed that all the tools are similar in the range of information they represent for both groups (greater range is dedicated to OA patients). Also, they all have indicated more scattered results (and significant greater amounts for variance and std but smaller mean value) for patient group. This shows the predomination of the source of disease the subject is suffering from to the measurement tool being selected to analyze the system. KSE significantly varies when the signal length is enlarged at least for three times in scale (for N0 at least 3000 data to N1=3*N0). But a slight oscillation is observed in SampEn subjectively which is interpreted as the uniqueness of motor control variability that must be compared to self-parameters of an individual, but not generalized as a tool's features.
Keywords: Entropy analysis, Kolmogorov-Sinai (K-S) Entropy, Approximate Entropy (ApEn), Sample Entropy (SamEn), Detrend Fluctuation Analysis (DFA), Chaotic system, Gait, Osteoarthritis, Knee

Innovation diffusion: a two-parameter competition model of mobile market

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The 2-parameter model for mobile market dynamics was proposed. Main character to be taken into account is that this market is oligopoly, the number of actors is few, and they strive for limited resources (users of mobile phones). Following parameters referred to real data were used: the average price per minute of traffic of the operator, and average traffic per operator. Results of numerical simulations are presented. We studied the case when operator tries to attract more new customers, and thus leads “price war”, introducing low tariffs and/or having aggressive advertising. This model can be treated as an approach to study innovation diffusion in mobile market: the change of number of customers in different segments (much talking, much spending, etc.) can be interpreted as the level of innovation acceptance.
Keywords: Chaotic modeling, Simulation, Forecast,

Detecting coherent sets with spacetime diffusion maps

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Intuitively, coherent sets are subsets of the configuration space that stay together under the (possibly chaotic) dynamics. Many different approaches for making this notion precise exist in the literature. For example, one approach defines coherent sets via spectral properties of the transfer operator, and another defines coherent sets as tight bundles of trajectories by specifying a euclidean distance metric in spacetime. We show that these two approaches can be reconciled: By replacing the Euclidean distance in spacetime with an augmented version of the distance used in diffusion maps, one can make contact with the transfer operator notion of coherence in the infinite data limit. The resulting numerical method, which can be used to extract coherent sets directly from trajectory data, is related to similar methods that have been discussed in the past. We demonstrate its performance on several examples.

Metal-Insulator Phase Transition in a Nanocrystal: A Quantum Chaos Approach

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Charge transfer and conductivity properties of a Nanocrystal lattice are studied via a disordered tight-binding model. In this work, we have reported an extended tight-binding model by considering electron hopping to next nearest neighbor in addition of nearest neighbor hopping. The significant aim is to study different transport regimes of system based on spectra analysis of energy levels and determining the critical regime and metal-insulator transition. The research is based on the distribution of consecutive level spacing ratio P(r). The results indicate that in absence of next nearest neighbor hopping, the system shows the localized behavior and its electrical nature corresponds to insulators electrical behavior. But, by increasing the hopping constant value, the system experiences a metal-insulator transition. The results show that by approaching the hopping constant value to 4, the relevant distribution is fitted on Wigner diagram and as a result the conductivity phase of system is transmitted from insulator to conductive phase.
Keywords: Quantum chaos, Tight-binding, Metal-insulator transition.

Dynamics of Proton and Electron conductivity in DNA Chains

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The transport of energy, mass, and charge along quasi one-dimensional hydrogen-bonded systems is an extremely important scientific problem. It is in close connection with basic properties of life, such as proton transport across biological membranes, and its implication to fundamental properties of condensed-matter materials, and proton mobility and electrical conductivity in DNA molecules. Charge transfer mechanism in DNA nanowires is studied through the different experimental and theoretical models. In this regard, Su-Schrieffer-Heeger (SSH) and Peyrard-Bishop-Holstein (PBH) models are the approaches considered the coupling of charge and DNA lattice. It seems that for a more comprehensive insight of charge transfer nature of DNA, we could consider the close relation between the electron and proton (Hydrogen atom) in lattice. Therefore, we have focused attention on proton coupled electron transfer (PCET) mechanisms in DNA. The coupling between proton motion and electron transfer plays a vital role in electrochemistry, photosynthesis, respiration, numerous enzyme reactions. In this work, we have tried to investigate the charge conduction by regarding to the effect of proton transfer along DNA base pairs. The charge transfer mechanism in DNA is a complex topic and coupling with proton transfer has added to its complexity. Since, studying this phenomenon using the conventional methods looks hard, we have tried to plan the novel framework for investigating the circumstance. We

have chosen the nonlinear dynamics systems methods and studied the system using the chaos theory. For choosing the best values for system parameters in which the system behaves orderly, we have used the mean Lyapunov exponent (MLE). On the other hand, DNA shows a multifractal nature when electron together with proton flows through it. We have compared the multifractal behavior of two sequence of DNA when by considering the PCET using the Renyi dimension spectrum.
Keywords: Hydrogen-bonded systems, DNA nanowires, Proton coupled electron transfer, Chaos theory, Mean Lyapunov exponent, Multifractal, Renyi dimension.

Study of accidents scenarios related to chemical process

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Chemical industries process often have large inventory of hazardous chemicals, and process area is often highly congested with the presence of complex piping and various other equipment necessary for process operations, such as high pressure compression, separation, storage, and blending. These operating conditions can lead to industrial accidents that threaten human life, the environment the facilities and the equipments. It is well-known that among all accidental process-related events, fires and explosions are the most frequently reported loss-producing events. To prevent any such unwanted situation, industries have adopted different methods of hazard identification and accident prevention. Quantitative risk assessment and management is one of the most popular methods. Accident scenario analysis techniques are essential not only in learning lessons from unfortunate events
In this paper we propose an approach for analyzing the scenarios of an accident related to a chemical process. The approach used in this paper is based on following steeps: Risk analysis, identification of top event, developement of the top event. We consider the case of a chemical reactor for the application of this approach.
Key words: Thermal runaway, HAZOP method, FMEA method, chemical process, chemical reactor.

Stability and chaos in a prey-predator model

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In this work we present a dynamical system and its chaotic behavior, different tools for qualitative and quantitative studies are explored and applied to a topical discipline: ecology, preciesly we study the evolution of populations in a continuous-time prey-predator ecological model.
Keywords: chaos, prey predator, stability, bifurcation.

A Predictable Chaos

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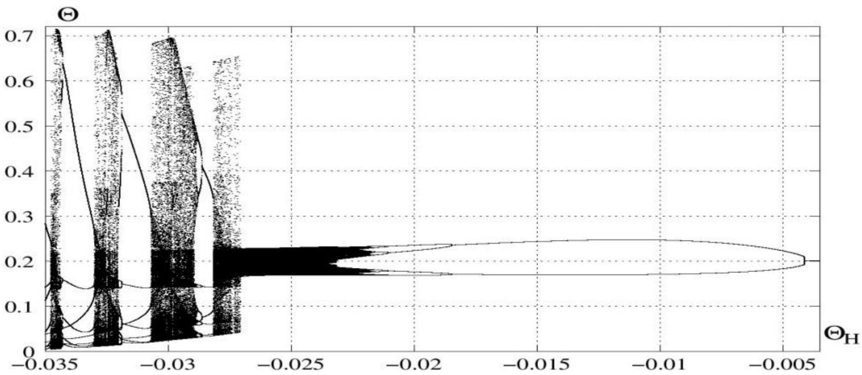
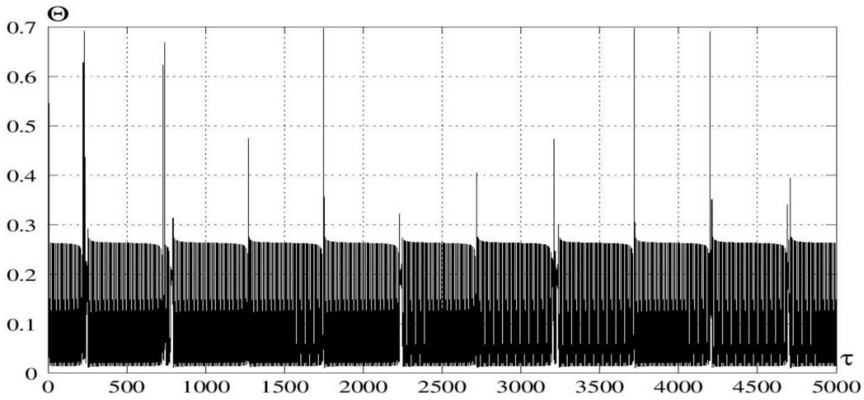
The main feature of chaos is unpredictability. It turns out that there are cases where this rule is broken. An example is a time series of temperature in the tubular chemical reactor with mass recycle [1,2]. For certain parameters values solutions are chaotic (see Feigenbaum diagram below) [1].



Intermittency appears on the border of periodic and chaotic solutions [2]. It has a special character, because explosions of intermittency occur at regular intervals. In this case at every 479 time units (see figure below;).



This predictability can protect the reactor from overheating and damage.

Keywords: Chaos, Time series, Chemical reactors, Intermittency, Feigenbaum diagram.

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Numerical visualization of attractor in material scale analysis and characterization

Fairouz Bettayeb, Boubaker Boussiala, Amar Boutaghane
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Welded components remain difficult to reliably examine cause of their complex thermal solidification process. Usually material's grains orientations cause waveform divergence and splitting due to the re-melting process after each welding pass. Added flaw data visibility by non destructive methods as ultrasound is somewhere corrupted by many noises as electric, pulse, ringing, and spurious signals. Various signal processing techniques were investigated to extract and interpret useful waveform data for diagnostic and predictive purpose. However the complexity of the model order estimation carries on complicated modeling. Wavelet based auto regressive parametric model could be a successful technique to withdraw non stable characteristics of data. In this paper waveform multi scale analysis was investigated under a predictive approach for data extraction. This analysis based correlations, residuals and in terpolations calculus seems to be a good tool for shaping the material micro structural dimension scales. This research displays a linear waveform micro structural distribution correlated to the matter phases and several curved layers who result on a Lorenz like attractor form whose modeling by inverse approach could be sound as a predictive indicator of material scales characterization

Keywords: Linear and nonlinear complexity, Multi scale analysis, Material characterization, Numerical modeling, Simulation

Lagrangian coherent structures in fusion plasmas

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Magnetic field lines embedded in a plasma confinement system are often characterized by a chaotic motion. This weakens the confinement properties of any magnetic configuration. However, even in case of chaotic domains, magnetic barriers can emerge and limit the field line motion itself. In the context of the numerical simulation of a Reversed-Field Pinch (RFP) configuration a new magnetic topology analysis, borrowed from previous fluid dynamic studies, is discussed. This methodology relies on the behavior of the Finite Time Lyapunov Exponent (FTLE) associated with the magnetic field. By referring to a previous work in which the magnetic field is given in terms of analytical function the FTLE field shows the presence of ridges, special gradient lines normal to the direction of minimum curvature, forming magnetic barriers. These ridges can be recognized as Lagrangian Coherent Structures (LCSs) for the system, actually opposing the penetration of magnetic field lines across them. In this article a more general numerical scheme for the detection of the LCSs has been adopted that allows analysis of realistic cases in which the magnetic fields are numerically known on a discrete mesh. After a validation test performed on the analytical case, a first application to a numerical magnetohydrodynamics simulation of the RFP, characterized by a broad chaotic region, has been performed. A strong magnetic barrier has been observed that effectively limits the field lines motion inside the chaotic sea.

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TRACE OF NEURAL NETWORK IN CHAOTIC ATTRACTOR

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In this paper, we discover that Hopfield's type of neural network can generate multi dynamic behaviors. We design some Hopfield's type of neural network with two different structures of models. Then once we stimulate these neurons by chaotic attractor, we notice that the dynamic behavioral response contains impact of neuron such as, signals of neurons with different directions. The results reached in this work shed some light on Henry Poincarre's conjuncture. Finally the numerical examples will illustrate the effectiveness of this work.
Keywords: Hopfield neural network, signature of neuron, bounded region, Chua attractor, signature of neuron.

Kinetic Glassy Transition in Ultrathin C60 Film on WO2/W(110) surface

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The glassy transition and nonexponential relaxation in solid C60 are due to the freezing of weakly correlated orientations of nearest-neighbor molecules. In bulk C60, the molecules can occupy two rotational orientations which are almost equivalent in energy but are separated by a potential barrier, and these orientations are distributed in a random fashion over the sites of an fcc lattice. The relaxation of solid C60 is determined by the potential barrier between these two states. All individual molecules in solid C60 occupy equivalent positions in the fcc lattice; each molecule relaxes nearly identically in an intrinsically nonexponential manner according to a homogeneous scenario. In contrast, the low-temperature glassy state of the C60 film is characterized by a random orientation of the molecules. The kinetic behavior of the C60 monolayer grown on the WO2/W(110) surface has been studied using low temperature scanning tunneling microscopy (STM). The large number! of different molecular orientations observed in the film results in an averaging-out of the interaction potentials and should cause Arrhenius-like relaxation processes. However, STM experiments reveal correlations in the nanomotion of the C60 molecules that suggest arguments in favor of a constrain-dynamic scenario. The observation of a glassy transition at 220 K reveals a nonexponential

relaxation in the C60 monolayer. The Kauzmann temperature was estimated to be 45 K.

Keywords: Nonexponential relaxation, Kinetic glassy transition, Ultrathin film.

DYNAMICAL COMPLEXITY IN TIME SERIES FROM KEPLER FIELD: FROM ASTROPHYSICAL NOISE TO EXOPLANETS

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Time series analysis is an enormous field of study in mathematical statistics, econometrics, signal processing, and other fields, among them, astronomy. Using a wide array of statistical tools including entropy concepts and complex systems theory, the present working plan proposes to investigate time series that exhibit variabilities in a very broad spectrum of research interests, ranging from astrophysical noise, rotational modulation and pulsation to planetary transit and explosive events. In my post-doctorate proposal, we intent to develop a powerful statistical environment for study of nonstationary, nonlinear, quasi-periodic, unevenly spaced, and non-equilibrium time series in astrophysics. For that, our research will point toward the stochastic processes associated to dynamical complexity and chaos in time series from Kepler spacecraft telescope. No doubt, dynamical complexity is a phenomenon expected to be observed in astrophysical time series when normal and abnormal states (e.g. pre-storm activity and magnetic storms) are detected. In this context, distinct physical effects in the stellar photosphere associated to large and short variabilities and multifractal structure can be discriminated using diagnostic tools for forthcoming extreme events. In our case, these phenomena are characterized by an entropic index q which leads to a nonextensive statistics. In several scenarios, time-dependent q-entropy effectively detects with a high precision small and crucial details in dynamics of the signal, where the vast majority of statistical techniques fails. In this review, we aim to acquire methods and techniques that explain: i) in general, how to treat phenomena of stellar variability in the context of nonextensive statistical mechanics; ii) in particular, how to detect effects of astrophysical noise at different time scales, and; iii) how to minimize the influence of ctivity cycles and recover planet signatures around cycling stars.

A Network of Coupled Crystal Oscillators for Precision Timing

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Precise time is crucial to a variety of economic activities around the world. Communication systems, electrical power grids, and financial networks all rely on precision timing for synchronization and operational efficiency. No later than Harrison's time, it was realized that precise time-keeping devices having the same stable frequency and precisely synchronized could have important applications in navigation. In modern times, satellite-based global positioning and navigation systems such as the GPS use the same principle. However, even the most sophisticated satellite navigation equipment cannot operate in every environment. In response to this need, we investigate a network-based approach for developing a high-precision, inexpensive, Coupled Crystal Oscillator System and Timing device (CCOST). Preliminary results from computer simulations seem to indicate that timing errors decrease as 1/N when N crystals are coupled as oppose to 1/square-root(N) for an uncoupled assemble. In this paper we employ equivariant bifurcation theory to provide a complete classification of the various patterns of collective behavior that are created, mainly, through symmetry-breaking bifurcations. The ultimate goal is to create a compact, inexpensive, CCOST network device with performance on the order of 1 ppb (parts-per-billion) accuracy or 10-09 sec.
Keywords: Networks, Crystal Oscillators, Symmetry, Bifurcation, Synchronization, Precision Timing, Navigation.

The invariant representation model of a situation for the automatic summarization system

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The research and modeling of some aspects of the texts and speech understanding process by a human, which are taken in different areas such as the study of brain work mechanisms (G. Hawkins), the development of strategies for the discourse understanding (A. Van Dijk), the modeling of abstracting process (O. V. Lazarenko) etc., directly and indirectly confirm the fact that a person in the process of recognition and comparison of objects and situations uses the most important characteristics which are stored in his memory in the shape of invariant

forms. In our work we propose the model of semantic text analysis which allows to provide higher quality of automatic summarization by selection of the macrostructure of the text and automatic formation of situational models in the form of text databases, using them to construct invariant representation of situations for extracting from the text the information required for the construction of the abstract.
Keywords: the language structure, comprehension strategies, invariant representation, semantic text analysis, modeling, automatic summarization

A chaotic decomposition method into a linear harmonic oscillator with nonlinear feedback

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The concept of oscillation in chaotic dynamocs is intriguing. Strictly speaking oscillation should refer to periodic motion only, with the term fluctuation being left for irregular or unpredictable evolution, such as chaotic motion. We also know that, in theory, chaotic oscillators are composed by an infinite amount of frequencies. In practice, however, there is a sort of cut-off frequency point where the remaining higher frequencies can be discarded, with negligible impact to chaotic dynamics. Besides, it is kind of acknowledged that chaotic oscillators present some sort of frequency of oscillation, despite the fact that this concept from classic harmonic theory does not fit in neatly. For instance, chaotic oscillators in analogue electronics can be pushed to "oscillate" in high frequency domain by manipulating the time constant of discrete components values (mainly resistors and capacitors).
These discrepancies, or even contradictions, in the theory pushed us to study chaotic oscillators with a fresh approach, analysing their composition according to their mathematical structure and making use of control theory techniques. Firstly, since the nonlinearities for low-dimensional chaotic systems are rather mild, we decomposed these by a linear and a non-linear part. Afterwards we concentrated our efforts in analysing the nonlinear part only with stability and pole placement tools. We came to realise that introducing minor system changes in their mathematical architecture we can effectively force the linear part to have their poles placed in the imaginary axis, such as harmonic oscillators. In this way, we can successfully reduce a chaotic oscillator in a classic harmonic, linear oscillator plus with a nonlinear feedback, that contains the nonlinearities and the cancellation terms for the linearisation applied. Thus, the dynamics can be chosen harmonic or chaotic depending on open or closed loop operation respectively.

We tested the method successfully with various chaotic oscillators, including Lorenz, Rossler, Chua, Colpitts, Duffing and Van der Pol with similar poles, suggesting the universality of the scheme suggested.
Keywords: Chaotic oscillators, harmonic oscillators, pole placement, nonlinear feedback, chaotic decomposition

Interplay of Turing and Wave instability in a three variable reaction-diffusion model

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We use a three variable reaction-diffusion model that accounts with two different diffusion coefficients mimicking those chemical reactions occurring in a microemulsion, such as the Belousov-Zhabotinsky reaction confined into AOT nanodroplets. Our parametric phase space focuses on the pattern formation observed on the onset of two different diffusion driven instabilities, namely the Turing and wave instabilities. Our numerical results show how the interplay between both instabilities generates novel and complex spatio-temporal dynamics, going from spatiotemporal intermittency to patterns with temporal alternating symmetry.
Keywords: reaction-diffusion, self-organization, pattern formation, diffusive instabilities, Turing patterns

The research of phase transformations order-disorder in NiAl and CuZn alloys of equiatomic compositions

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Using BCC-alloys NiAl and CuZn as an example, it is shown by the Monte Carlo technique that the processes developed during thermal cycling in the course of structural phase transformations in BCC alloys are irreversible. As a result of a heating–cooling cycle, a certain hysteresis is observed, whose presence suggests an irreversibility of these processes, which is indicative of the difference in the structural-phase states in the stages of heating and cooling. In the course of order–disorder and disorder–order phase transformations has supported the difference in its structural-phase states in the stages of heating and

cooling. Upon completion of the disorder–order phase transition, two domains with B2 superstructure are formed in the both alloys. Analysis of atomic and phase structure of the system in the cooling process, i.e. during the phase transition order-disorder, showed the presence of elements to appropriate partial dislocations in the plane <100> and antiphase boundaries.

Keywords: Monte-Carlo, phase transformations, order, disorder, superstructure, B2, BCC-alloys, crystal.

In-situ uncertainty identification on many solver adaptive space-trees in the ExaHyPE project

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We present ExaHyPE, a spacetree-based solver for hyperbolic equation systems that is designed to exploit tomorrows exascale computing infrastructure. It combines multilevel, high-order DG with patch-based FV. We plan to use this engine to simulate gravitational waves and long-range seismic waves. Both application fields suffer from high uncertainty: parameters are only estimates or subsurface models are inaccurate.

This talk consists of two parts:

In the first part, we propose to implement classic in-situ convergence tests. For this we provide a many solver software environment that allows users to compare an arbitrary number of solvers working with different orders and mesh sizes. These solver variants can be inserted or removed from the grid on the fly.

In the second part, we propose to model uncertainties as random parameters in the PDE of the forward model and use an adjoint-based method to quantify whether chaotic perturbations may lead to significantly different results locally in space-time. If our solves predict such a scenario, we split up the forward simulation into multiple forward solves.

We show that the proposed method seamlessly integrates with the many solver software environment we discuss in the first part of this talk.

Keywords:

Hyperbolic systems, In-situ uncertainty identification, Many solver software environment, Adjoint-based approach

Chaotic synchronization between two dc glow discharge plasma sources via non intrusive coupling

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In synchronization studies, chaotic synchronization is one of the most important and challenging phenomenon which has a very wide application in the field of secure communication. Such phenomenon has been experimentally realized in different systems like electronic circuits, lasers and chemical oscillators etc. A plasma is a highly complex system which inherently produces different types of nonlinear oscillations and in certain conditions these oscillations also have chaotic properties. Synchronization studies by using these chaotic signals have very good potential to open new ways of chaotic synchronization, which can be utilized in secure communication. In this paper we report on experimental results of chaotic synchronization between two DC glow discharge plasma sources via non intrusive coupling.
Two DC glow discharge plasma sources whose cathode and anode diameters were 70 mm and 2 mm respectively and operating at a neutral pressure of 0.2 mbar have been used for chaotic synchronization experiments. Floating potential fluctuation frequencies of both the plasma chambers were measured by placing a cylindrical Langmuir probe in each of the chambers. It has been observed that with increase in the discharge voltage oscillations of both the chamber plasmas changes from periodic to chaotic oscillations. We have fixed the oscillations of one of the chamber plasmas in chaotic regime and other in periodic regime such that peak frequency of chaotic oscillations was close to the periodic oscillation frequency of other chamber. After this we have established a coupling between the oscillations of the two chamber plasma by winding a few turns of copper wire outside the two glass chambers and placed on top of the two cathodes. It has been observed that as the coupling was established, periodic oscillations changed into the chaotic oscillations and become synchronized with the chaotic oscillation of first chamber.
Key Words: Chaotic Synchronization, Non intrusive coupling

Magnetic coherent structures in space plasmas

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We study coherent structures in solar photospheric flows in a plage in the vicinity of the active region AR10930 using the horizontal velocity data derived from Hinode/Solar Optical Telescope magnetograms.

Eulerian and Lagrangian coherent structures (LCSs) are detected by computing the Q-criterion and the finite-time Lyapunov exponents of the velocity field, respectively. Our analysis indicates that, on average, the deformation Eulerian coherent structures dominate over the vortical Eulerian coherent structures in the plage region. We demonstrate the correspondence of the network of high magnetic flux concentration to the attracting Lagrangian coherent structures (aLCSs) in the photospheric velocity based on both observations and numerical simulations. In addition, the computation of aLCS provides a measure of the local rate of contraction/expansion of the flow.

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Entropy-complexity analysis in some globally coupled systems

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Recently, Rosso and coworkers have introduced a representation space, the entropy-complexity causality plane [1], as a novel tool to analyze the chaotic and/or stochastic nature of dynamical systems. This offers the possibility of a visual representation of the respective weights of the chaotic and stochastic (noise) components in maps.

In this study, we first discuss the applicability of the entropy-complexity frame to time series. Then, we propose to consider it as a new complementary tool to analyze the dynamics and transport properties of some N-body globally coupled systems. These systems are well-known to possess an intricate dynamics. Moreover, when N is large, collective effects may drastically lower the effective dimension of the dynamics impeding the applicability of statistical mechanics.

The Hamiltonian Mean-Field (HMF) model [2] is the Hamiltonian counterpart of the well-known Kuramoto model. Here the repulsive HMF is used as a globally-coupled toy model. Computing the entropy and complexity of time series of the mean-field at various energy densities, this approach enables to uncover a transition of the system dynamics from low-energy non-Boltzmann quasi-stationnary states to high-energy stochastic-like behavior [3].

Keywords: Deterministic chaos; stochasticity; entropy; complexity; long-range interacting systems; mean-field models.

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Invariant measure of a bounded iteration in $\mathbb{R}^{\mathbf{d}}$

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We search invariant measures under a polynomial iteration in a bounded set of $\mathbb{R}^d$. We use the Perron Frobenius to define these measures. We find such measures with the method of the steepest descent. These measures are few dimensional. But, the conditions of existence of these measures are often difficult to realize in the real world.

Keywords: Bounded iterations, chaos, invariant measures, Peron-Frobenius

Landscape and Complexity of Nonlinear Waves

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We will review our work on the introduction of ideas of statistical mechanics of disordered systems in the study of nonlinear regimes, ranging from random lasers to solitons and rogue waves

Interaction of scroll waves in an excitable medium: Reconnection and repulsion

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Spiral waves occur in systems ranging from biology to astrophysics, fluids to superconductors. Scroll waves are the 3D counterparts of spiral waves that rotate around a one dimensional phase singularity, known as filament. Their presence in the cardiac tissues is many times the cause of tachycardia and fibrillation that finally lead to heart failure. So the interaction of scroll waves may have far-reaching consequences on cardiac activity. In fluids and liquid crystals, there is evidence of vortex

interaction leading to interesting phenomena like filament reconnection. If likewise, scroll rings interact and reconnect, then small rings may merge and form large ones that will have enhanced life-times. If this happens in heart tissues, it will ensure a long life of the filaments which in turn will have a detrimental effect on cardiac health. The work reported here is motivated by these concerns. Here, we report the first experimental evidence of scroll wave reconnection. Our results demonstrate that when two scroll rings are brought close enough, they can either attract each other, and reconnect to form a large scroll ring, or they can repel so that they rupture on touching the boundaries. We also carry out simple numerical simulations that helps explain the filament behavior in our experiments.
Keywords: Scroll waves, cardiac activity, reconnection and repulsion, Belousov Zhabotinsky (BZ) reaction.

Experimental results on chaotic intermittency

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Intermittency is a specific route to the deterministic chaos when spontaneous transitions between laminar and chaotic dynamics occur. The main attribute of intermittency is a global reinjection mechanism described by the corresponding reinjection probability density (RPD), that maps trajectories of the system from the chaotic region back into the local laminar phase.
Recently, we generalize the classical analytical expressions for the RPD in systems showing Type-I, II, and III intermittency. As a consequence, the classical intermittency theory is a particular case of the new one. We present an experimental confirmation of some results of this new intermittency theory, even in the case of noisy experiment.
Keywords: Intermittency, Chaotic modeling, one dimensional map, Electronic circuits, Noise.

Heat bath. The case of Thermal ocean currents as open thermodynamic systems

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Water is a unique compound and is found in abundance in nature in all three forms, solid, liquid and gas. These qualities of the great solvent

capacity, create and define more processes in the Earth's crust, such as climate, soil erosion and energy transport, and the creation and preservation of life. The physicochemical properties are due to the chemical composition of two hydrogen atoms and one oxygen atom. The temperature, salinity and pressure determine the density of water. Because these three parameters are variables, the transfer of energy from warmer to colder places, such as the warm Gulf Stream, we can not have a fixed and linear continuity of processes of these, but the prediction and the possible calculation is different at certain intervals. According to the second law of thermodynamics we have: dS total=dS+dS0.
Where: ds= the alteration of system entropy and dS0= the alteration of heat bath entropy.
Keywords: heat bath, gulfstream, open thermodynamic system, heat transport.

Transfer Operator Families and Coherent Sets

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The computation of sets in phase space of a time dependent dynamical system which are separated by transport barriers, so called coherent sets, is of interest for systems which often show chaotic behaviour, e.g. atmospheric flows or plasma physics. In this talk we present a way to compute those finite-time coherent structures via considering the system at all time instants. This is done by analysing a corresponding transfer operator family as a whole. We furthermore discuss different discretizations, some of them leading to recently developed, purely data-driven algorithms and so providing a set oriented justification for those.

Bifurcation Analysis of Regulation of Bursting Discharge in DRG Neurons

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We examine the task of suppression of ectopic bursting discharges in dorsal root ganglion (DRG) of nociceptive neurons of rats. For solving the task we apply methods of bifurcation analysis of the DRG neuron model (Kovalsky et al. [13]) modified by including the TTX-resistant NaV1.8 sodium channels in the system equations. It allows us to partition the parameter plane of the model into the regions corresponding to stable steady states, stable periodic solutions and bursting discharges

and to find the system bifurcation parameters changing in which determine boundaries of the considered regions. We have shown that namely changes in parameters leading to modification of the NaV1.8 sodium channels are responsible for switching off the ectopic bursting discharges. These changes cause a decrease in the effective charge transferred through the activation gating system of these channels in the membrane of the DRG neuron and reflect the specific action of comenic acid (5-hydroxy-γ-pyrone-2-carboxilic acid), which is a drug substance with a strong analgesic effect (Dick et al. [5]) Thus, our results explain the molecular mechanism of the analgesic suppression of ectopic bursting discharge in the nociceptive neuron.

Keywords: Bifurcation analysis, Fast and Slow variables, Bursting discharge, Suppression of neuropathic pain, DRG neuron model.

Exploring Strange Behaviour of Binomial Distribution Fitting to Online Ratings Data

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In last year CHAOS2015 conference the nonlinear behavior in fitting of Simple Binomial and Mixed Binomial Distribution to 5-star rating data presented and explained. In this work the time evolution of this behavior investigated using both real and simulated data from the Binomial Distribution. Real 5-star ratings data of several hotels around the world from TripAdvisor used as testing sample. Also simulated data generated by Binomial Distribution B(n=4,p) used to explore the relationships with real data.

Keywords: Binomial Distribution, False Rate, Online Rating, Non-Linear Regression, Five Stars Rating, TripAdvisor, Binomial Data Simulation.

Lump solitons in a higher-order nonlinear equation in 2+1dimensions

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We propose and examine an integrable system of nonlinear equations that generalizes the nonlinear Schrödinger equation to 2+1 dimensions. This integrable system of equations is a promising starting point to elaborate more accurate models for describing energy transfer processes in alpha-helical proteins within the continuum limit. The Lax pair for the system is derived after applying the singular manifold

method. We also present an iterative procedure to construct the solutions from a seed solution. Solutions with one, two and three lump solitons are thoroughly discussed.

Sub-harmonic frequency lock-in and vortex shedding synchronization due to regular and irregular surface waves

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The influence of harmonic surface waves and surface waves with irregular amplitude and phase modulation on turbulent Kàrmàn vortex street is investigated experimentally. The experiments are performed in hydrodynamic flume, where Kàrmàn street occurs behind vertical circular cylinder streamlined by steady current. The surface waves propagating upstream are excited by computer controlled wave maker. It is found that sinusoidal surface wave can modify regime of shedding in Kàrmàn street: sub-harmonic frequency lock-in and phase synchronization arise if the frequency of wave is approximately two times more than the frequency of vortex shedding in Kàrmàn street. A region of frequency lock-in is found on the plane “amplitude-frequency” of surface wave.
Synchronizationlike phenomenon is found also for the case of irregular suface waves. In our experiments the irregular waves have a continuous spectrum in the finite frequency interval. The peak frequency in surface wave spectrum differes from double frequency of vortex shedding. The dependence of the vortex shedding spectra on the amplitude of the surface waves has beeen studied. It was found that the increase in the surface wave amplitude tends to make the shedding peak frequency to be close to half of the peak frequency of the surface waves. For a more detailed study of this effect, Hilbert transformaion is applied. Using this transformation phase of surface waves Pw and phase of oscillation in the Kàrmàn vortex street Pk are calculated. The dependence of phases combination P = 2*Pw-Pk on surface wave amplitude is studied. It is revealed that time dependence of P has steplike shape: time inteval with P const corresponding synchronizationlike effect interspersed with fast changes in P It is shown that the time of synchronization increases with the ampltude of surface wave.
Keywords: Surface waves, von Kàrmàn street, Frequency lock-in, Synchronization.

Entropy, chaos and independence in symbolic dynamics

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Two extensions of classical results in symbolic dynamics will be presented.
The first result describes in what sense positive entropy may be understood as independence. It states that the positive topological entropy of a shift space is equivalent to the existence of an independence set for which asymptotic and Shnirelman densities are equal and positive. This shows that, for a shift space with positive entropy, one can find an independence set which is large and structured.
The second result is connected with a result of Weiss, who constructed a transitive shift space with a dense set of periodic points and no ergodic invariant measure of full support. He also noted, omitting the proof, that his example is in fact topologically mixing and has zero topological entropy. Furthermore, Weiss conjectured that the only ergodic measures for his system are those concentrated on the orbit of a single periodic point.
During the talk a similar example will be presented. The system will possess all the properties proved or conjectured about the example from cite{Weiss73}. Furthermore, the defined system do not possess any distributionally chaotic pairs, is omega-chaotic, but isn't omega*-chaotic.
Keywords: topological entropy, distributional and omega-chaos, symbolic dynamics

Chaos Assessment in Economic Time Series through Multi-Resolution Analysis of the Lyapunov Exponent

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Deterministic chaos is characterized by sensitivity to initial conditions, which can be detected by measuring the rate of divergence between two trajectories which started from nearby states. Lyapunov exponent – routinely used in defining chaotic dynamics – has been designed to assess such a behavior. However, evidences of chaos in a given experimental system has to be evaluated on empirical basis, namely by direct observation of the empirical data. Such a framework involves two main problems: the first one is related to the experimental nature of the data which – even though to different extent – are always affected by noisy components. In fact, either in the form of environmental fluctuations or limited experimental resolution, noise can introduce significant amount of uncertainty in the system under investigation and chaos can go undetected as a result. The second problem is related to the fact that the estimation of the Lyapunov exponent, being performed

on trajectories of finite length, can be severely biased due to their insuficient duration.
In the present paper it is shown how sensitivity to external noise and poor resolution of data can be counteracted by carrying out the estimation of the Lyapunov Exponent within the framework of multi-resolution approximation (MRA). The first problem is tackled using the MRA low-pass filtering capabilities, whereas experimental lack of resolution can be compensated by investigating Lyapunov Exponent's behavior at different resolution levels. By probing small length scales, detection of non-linear phenomena as well as better understanding of their nature can be also gained.
Finally, the whole analysis is corroborated by an extensive empirical study involving monthly economic time series as well as high frequency data.
Keywords: Lyapunov Exponent, Muliresolution Analysis, Economic time series.

Differential Equations of Ellipsoidal State Estimates for Bilinear-Quadratic Control Systems under Uncertainty

Tatiana F. Filippova
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The problem of describing the reachable sets of nonlinear dynamical control systems with combined bilinear and quadratic nonlinearity and with uncertainty in initial states is studied. We assume that the uncertainty is of a set-membership kind when we know only the bounding set for unknown items and any additional statistical information on their behavior is not available. Applying results of the theory of trajectory tubes of control systems and related techniques of differential inclusions theory we present new approaches that allow finding external or internal ellipsoidal estimates of reachable sets. The main result consists in obtaining the differential equations describing the dynamics of centers and matrices of the external ellipsoids estimating the reachable sets of the bilinear-quadratic control system under uncertainty. Examples and numerical simulations related to the proposed techniques and illustrating the theoretical results are also included.
Keywords: Control systems, Nonlinear dynamics, Estimation problem, Set-membership uncertainty, Ellipsoidal calculus, Funnel equations, Trajectory tubes, Simulations for uncertain systems.

Evolutionary photonics: a review of recent results

Andrea Fratalocchi
KAUST, Saudi Arabia

Evolutionary photonics takes inspiration from natural systems and phenomena such as chaos and unpredictability, creating new technologies in material science, energy harvesting and nanomedicine. In this invited talk, I summarize my research activity in the field, discussing recent results including chaotic energy harvesting (Nat Phot 7 474 2013), the control of subwavelength and ultrafast rogue waves (Nat Phys 11 358 2015), the development of disordered sensors for early-stage cancer detection (Science Advances, 2015), and finally a new generation of black-body "lasers" (Nat Nanotech 10 11 2016).

Global Analysis of Bifurcations and Chaos in Low-Dimensional Dynamical Systems

Valery Gaiko
National Academy of Sciences of Belarus, Belarus

The global qualitative analysis of low-dimensional polynomial dynamical systems is carried out. First, using new bifurcational and topological methods, we solve Hilbert's Sixteenth Problem on the maximum number of limit cycles and their distribution for the 2D general Liénard polynomial system and Holling-type quartic dynamical system. Then, applying a similar approach, we study 3D polynomial systems and complete the chaos transition scenario for the classical Lorenz system connecting globally the homoclinic, period-doubling, Andronov-Shilnikov, and period-halving bifurcations of its limit cycles which is related to Smale's Fourteenth Problem.
Keywords: Polynomial dynamical system, Bifurcation, Limit cycle, Chaos.

Experimental Detection of Wave Chaos in Quasi-Optical Microwave Cavity Resonator

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Microwave resonant structures of spherical (cylindrical) geometry contained inhomogeneous inserts in the form of a metal sphere (disk)

has been studied. The inner sphere (disk) is located either symmetrically or non-symmetrically with respect to the structure's side walls. For each of these states, the resonant frequency spectrum was measured in the 8-mm waveband. The correlation factors between the interline frequency intervals has been calculated. The symmetric spherical or cylindrical resonant structures with an inner sphere (disk) show correlation factors close to zero, whereas non-symmetric layered spherical structure where the inner sphere (disk) is placed asymmetrically has correlation factors C(1) > |0.2|. A transition between such states may occur within a narrow range of the structure's eccentricity. The probability distribution of the inter-line intervals has been calculated also. In the case of integrable systems these dependences are practically similar to the Poisson distribution, while the non-integrable system dependences tend to Wigner distribution which demonstrates the spectral line repulsion and can be a sigh of wave chaos in the given resonant structure.
Keywords: Quasi-optical microwave cavity resonator, correlation factors, wave chaos.

Determination of the Basin of Attraction by Computing Contraction Metrics

Peter Giesl
University of Sussex, England

The determination of the basin of attraction of an equilibrium or periodic orbit can be achieved by different methods. In this talk, we discuss a local method using a contraction metric, i.e. a Riemannian metric with a local contraction property. It can be used to prove existence and uniqueness of an equilibrium (or periodic orbit) and determine a subset of its basin of attraction without requiring information about its position. We present a method to numerically construct such a contraction metric. The contraction metric is characterised as a matrix-valued function, satisfying a certain linear PDE. Then it will be approximated by meshless collocation, in particular Radial Basis Functions. We will present error estimates as well as numerical examples. This is joint work with Holger Wendland, University of Bayreuth, Germany.

Anthropogenic Seismicity in Colombia: quantitative probabilistic approach

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It is know that tectonic stress, pore pressure, fluid migration and strain variations can be generated by human operations. The response of earth to these changes is manifested in the occurrence of earthquakes known as anthropogenic seismicity. These kind of seismicity can be induced or triggered and its discrimination from natural seismicity is a difficult task, and specific methods have not been well established yet. The first approaches to assess the probability of an earthquake is or not induced/triggered is given by a qualitative evaluation of some parameters related with historical seismicity and its relation in time and distance between plausible sources and events.
In order to make a more quantitative evaluation of anthropogenic seismicity, the objective of this work is to provide reasonable information about which events may be considered induced by analyzing the changes in parameter b over time. The methodology used consist of run some non-parametric distribution tests and evaluate the frequency – magnitude variations. Records are provided by the National Seismological Network of Colombia in areas close to the most productive oil fields in Colombia for the last 10 years.
Keywords: Anthropogenic Seisimicity, Frequency – Magnitude distribution, Non-parametric distribution.

A Diamond growth model with VES production function. The role of the elasticity of substitution

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The critical relationship between economic growth and elasticity of substitution between production factors plays a crucial role in the theory of economic growth. Several papers in literature studied this relation using production functions with Constant Elasticity of Substitution. In this work we analyze the connection between endogenous economic growth and elasticity of substitution using a production function with Variable Elasticity of Substitution. We explore the Diamond overlapping-generation model with Revankar production function, that is a VES production function, in order to inspect the relation between elasticity of substitution and attractors in the case in which they consist in cycles or more complex sets.
Keywords: Variable Elasticity of Substitution, Diamond Growth Model in Discrete Time, Fluctuations and Chaos, Bifurcation in Piecewise Smooth Dynamical Systems.

Self-organization in homeostasis of blood-vascular system of organism

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A mathematical model of the blood-vascular system of a human organism is developed. The functioning of the polyenzyme prostacyclin-thromboxane system of blood and the influence of the level of cholesterol on it are studied. By means of the computing experiment, the various modes disturbing the homeostasis of blood vessels are determined: hemophilia, thrombosis, periodic and chaotic autooscillations. The phase-periodic bifurcational diagrams, kinetic characteristics, and attractors in some modes are constructed. The total spectra of Lyapunov's indices, divergences, KS-entropies, predictability horisons, and Lyapunov's dimensions of the fractality of strange attractors are calculated. Some conclusions about the structure-functional connections determining the dependence of the homeostasis of a blood-vascular system on the level of cholesterol in blood are presented.
Keywords: Self-organization, homeostasis, chaos, blood-vascular system, prostacyclin-thromboxane system, Lyapunov's indices, KS-entropy.

Testing for Chaos through Lyapunov exponents

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Before forecasting "observable" dynamical systems using properties of chaotic systems, one has to test whether they exhibit local or global chaotic behavior. A known measure of chaos is the Lyapunov exponent. Several papers has been written on testing chaos through Lyapunov exponents: Gencay (1998), Linton (2001). Nevertheless, none of these methods estimate the power of the test. The power of the test is the probability to reject chaos when the system is not chaotic. It is a measure of test robustness. In this paper we propose a new test for chaos, we provide size and the empirical power of the test. Furthermore, we obtain asymptotic results concerning the ergodic measure of Lyapunov exponent distribution.
Keywords: Test, Lyapunov exponents, Bootstrap, Maximum Entropy

Performance improvement of Chaos Optical Time Domain Reflectormetry in attenuation measurement

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The optical time domain reflectometry (OTDR) has been an important diagnostic tool for testing fiber transmission systems and components. However, the pulsed OTDR suffers from a significant shortcoming which is the tradeoff between dynamic range and spatial resolution. In order to overcome this shortcoming, chaos optical time domain reflectometry (chaos-OTDR) was developed. In this method, continuous-time chaotic laser light is employed as a probe light, which has a random intensity fluctuation and a delta-like autocorrelation trace. The chaotic signal detection can improve largely the spatial resolution. However, currently, this technique can only be used to detect reflection events. As of now, fiber attenuation measurement by this method has not been reported. In this paper, we propose an improved chaos-OTDR technique to realize the measurement of fiber attenuation. In this technique, the electro-optic modulator (EOM) driven by a periodic-pulse generator is used to modulate the chaotic light, the pulse modulated chaotic laser is used as a probe light. The distance-independent high spatial resolution is obtained by cross-correlation between the reference and echo signal. Experimental results indicate that different fiber attenuation coefficients can be measured, which is good agreement with values obtained by a conventional OTDR. Furthermore, we achieved a 0.6-m spatial resolution under a 200-MHz data bandwidth.
Keywords: Chaos, fiber attenuation, optical time domain reflectometry (OTDR).

Transition from Chaos to Order in a Classical Yang Mills Higgs System

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Yang Mills theory is a gauge theory having a central role in our current understanding of fundemental interactions. Today most field theories of weak, electromagnetic and strong interactions are well described by gauge theories.Yang Mills theories are special example of gauge theory with a nonabelian symmetry group. Chaos to order transitions in a classical Yang Mills Higgs system is analyzed with the aid of Lyapunov exponents and Poincare sections. Addition of oscillatory term to the Hamiltonian of the corresponding system shows that there is a transition from chaotic behavior to regular motion as its intensity is increased. The maximal Lyapunov exponents of the system in a specific range of

parameters are calculated and the region where the chaos-order transition occurs identified with an eye on transition back to order.
Keywords: Dynamical systems, Lyapunov Exponents, Yang Mills Higgs, Chaos Theory, Poincare Section

Jerky Systems Derived From Sprott D and Sprott C Systems

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The Sprott C and D systems are among the three variable simplest chaotic systems with resonant characteristics and possible candidates for demonstrating Hopf Bifurcation. Investigation of Sprott systems for deriving jerky Dynamics has also become of interest. The jerky dynamics has been analyzed with approximating with a continuous function.
In this work, we will use slightly generalized forms of these two Sprott systems, derive jerky systems compatible with them, analyze their transition to chaotic behavior and their attractors using our two parametrizations for approximating discontinuous functions with continuous ones, one of which is the same as that used in the literature.
Chaotic invariants such as Lyapunov exponents and fractal dimensions have been calculated. Comparisons of these invariants between the normal and jerky systems have been analysed.
Keywords: Chaotic modeling, Chaotic systems, Sprott systems, Fractal dimension, Lyapunov exponents, Simulation, Chaotic simulation, Hopf bifurcation.

Multifractal Analysis of Digital Currency Parities

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Bitcoin has become more popular since 2009 because of its low transaction fees compared to credit card processors; easy, fast also peer-to-peer payment network. Moreover, a lot of different digital currencies like litecoin, ppcoin etc have been introduced after bitcoins success. In a previous study, we showed possible chaotic behavior by calculating positive Lyapunov exponents for the evolution of the bitcoin parities and find positive maximal Lyapunov exponents from daily exchange prices of bitcoin through 6 months in the year 2011 from June to October for different currencies. In this study, we perform additional

large data time interval and first calculate the generalized Hurst exponents and we deduce Renyi exponents, singularity spectrum of the bitcoin/usd/parity and bitcoin/euro/parity to detect the sources of multifractality.

Keywords: Time Series Analysis, Multifractality, Chaotic modeling, Generalized Hurst exponent, Renyi exponent, Singularity spectrum

Lyapunov functions on finite time intervals: theory and a computational method

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Lyapunov functions for nonautonomous systems on finite time intervals can deliver useful information on the qualitative and quantitative behavior of the system trajectories on that interval. A novel method using linear programming to parameterize such Lyapunov functions is studied and some theoretical and numerical results are presented.

On The Optimality of Generalized Fractional Cubic Spline with Applications

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In this paper, we introduce a generalized cubic spline method with fractional order and study with error optimality, convergence analysis and to find out an approximate solution for fractional differential equations. This method is proposed to be applicable for the fractional order as alpha in the interval (0, 1), where alpha denotes the order of the fractional derivative in the Caputo sense. Error bounded of this aim is chosen and discussed, some explained example are demonstrated and also it is compared for each example that value of alpha is changed for some values.

Keywords: Fractional spline function, fractional differential equations, Caputo fractional derivative, lacunary interpolation.

Data-based methods for Lorenz-86: A simple atmospheric model.

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The model used in this study is that of Lorenz (1986), as modified by

Wirosoetisno (2000), and will be referred to here as the extended Lorenz-1986 model or exL86. It has only 4 degrees of freedom, but admits both a fast gravity wave and a chaotic vortical mode, with an asymptotic, nonlinear balance between fast and slow variables. The advantage of models such as exL86 is that the balance between fast and slow variables is well understood, and the assimilated analysis can thus be easily interpreted in terms of the balanced and unbalanced components of the motion. The fact that this model is conservative does not pose a great difficulty, since the intention here is to use it to study kernel based algorithms in the context of the slow versus the fast variables. As pointed out by Lorenz (1986) and Wirosoetisno (2000), dissipation of gravity waves is not the cause of the existence of a slow manifold, and therefore models such as this one can be quite representative of realistic balanced dynamics. In this talk, we use kernel methods in (Bouvrie and Hamzi, 2011) for the data-based modelling of the Lorenz-86 model and show how we can detect the fast-slow dynamics.

Flattening Power Spectrum of Chaotic Semiconductor laser Using an Optical Filter

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We propose a simple method to improve the spectral flatness of chaotic light from an external-cavity feedback semiconductor laser using a fiber Bragg grating. The effects of detuning between the Bragg frequency and the laser frequency on the bandwidth and spectral flatness are both investigated. The method enhances the flatness of the power to ±1.4dB whilst maintaining the spectral bandwidth at around 8GHz. Furthermore, the energy of low frequency oscillation is increased, so that a low-pass spectrum is obtained. The experimental results are in accordance with theoretical predictions which also have shown that the spectral flatness decreases initially then increases with increasing the 3dB linewidth of grating. A flattened spectrum with a low-pass energy distribution increases the utilization efficiency of chaotic light in chaotic radar and reflectometry.
Keywords: chaotic light, semiconductor laser, fiber Bragg grating

The Numerical approximation of the invariant measure of levy driven stochastic differential equations

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A stochastic differential equation (SDE) is a differential equation in which one or more of the terms is a stochastic process, resulting in a solution which is itself a stochastic process. SDEs are used to model diverse phenomena such as fluctuating stock prices or physical systems subject to thermal fluctuations. However, most of the models are based on Gaussian noise, although, in recent years Levy randomness began to draw much attention. This is the case, e.g. if the random perturbation process should be used to model abrupt pulses or extreme events. A more natural mathematical framework for these phenomena takes into account perturbations other than purely Brownian, in particular Levy processes or general semimartingales with jumps. Levy randomness needs other techniques, is quite intricate and far from amenable to mathematical analysis. In case of monotonicity of the coefficients, one can show that there exists a unique invariant measure. This invariant measure characterize the long time behavior of such a solution. However, for most of the systems the invariant measure is not explicitly given and can only be found by numerical simulations. In our talk we will present some results concerning the numerical approximation of the invariant measure.

Impact of Interaction between Surface Waves and von Kàrmàn Street to the Bottom Sediments Transport

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The combined action of surface waves and von Kàrmàn street on sediment transport behind a circular cylinder is investigated in laboratory experiments. It was found recently (Gunnoo et al, Phys. Letters A, 2016) that under the action of surface waves, regime of vortex shedding behind a cylinder can vary significantly. Sub-harmonic frequency lock-in and synchronization can arise if frequency of surface waves is approximately two times more than frequency of naturel shedding. Large amplitude surface wave can excite symmetric vortex street instead of chess-like street and in this case frequency lock-in also occurs. If the amplitude of surface wave is sufficiently large vortex shedding is completely suppressed. In this report we investigate how regime of vortex shedding influences on sediment transport on the bottom.
Experiments were performed in hydrodynamic flume, where steady current was created by water pump; surface waves propagating

upstream were excited by computer controlled wave maker. The circular cylinder was placed vertically in the center of the flume. A specially designed profilometer was used to investigate the evolution of sandy bottom patterns appearing in the vicinity of the cylinder.
Under experimental conditions, flat interface between water and sandy bottom is stable relatively generation patterns far from the cylinder, if only steady current exists in the flume. In the vicinity of the cylinder scour is generated. We compare evolution of scour and sandy pattern in the wake of the cylinder for three different regimes: hydrodynamic current only, current + surface waves at regime of sub-harmonic frequency lock-in, and current + surface wave at regime of frequency lock-in. For each regime the time evolution of bottom profiles have been investigated in the region 1mx0.35m in vicinity of the cylinder. It was found that sub-harmonic frequency lock-in leads to intensification of vortices and formation of more regular structure behind cylinder in comparison with regime appearing for solely current. It was found that at regime where vortex shedding frequency coincides with the frequency of the surface wave, in the vicinity of the cylinder on the bottom sand ripples are generated with amplitude much greater than in the first and second regimes. It is shown that the increasing in sand ripples amplitude is due to the intensification of vortices in the wake of the cylinder caused by surface waves.
Keywords: Surface waves, von Karman street, Frequency lock-in, Synchronization, Sand ripples, Scour.

Controllable activation and inhibition of spiking patterns in Vertical Cavity Surface Emitting Lasers

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Photonic techniques emulating the powerful computational capabilities of cortical neurons are attracting increasing research interest as these offer exciting prospects for novel ultrafast neuromorphic computing systems [1-4]. One of these approaches uses Semiconductor Lasers (SLs), as they can undergo a wide variety of nonlinear dynamical responses similar to those observed in neurons but several (up to 9) orders of magnitude faster [5-7]. Amongst SLs, Vertical Cavity Surface Emitting Lasers (VCSELs) are ideal devices for neuromorphic photonics given their inherent advantages, i.e. reduced manufacturing costs, high coupling efficiency to optical fibers, ease to integrate in 2D arrays, etc. However, it is only recently that VCSELs have started to attract attention for novel photonic neuronal models [1,6-8]. In this talk, we will review our recent work on the achievement of reproducible and controllable spiking patterns in VCSELs operating at important telecom wavelengths (e.g.

1300nm and 1550nm). Specifically, we will show that a wide variety of spiking regimes, e.g. single and multiple spiking and bursting patterns can be controllably produced in these devices in response to externally induced perturbations [8]. Moreover, these spiking regimes are obtained with sub-nanosecond speed resolution and reduced recovery time offering promise for ultrafast non-traditional information processing capabilities. During our talk, we will also introduce our very recent results on the controllable inhibition of spiking patterns in VCSELs with nanosecond speed resolution. The reproducible/controllable activation and inhibition of spiking responses at high speed rates in VCSELs operating at telecom wavelengths offer great potential for the use of these devices in novel ultrafast neuromorphic photonic information processing modules for applications in non-digital computing systems and future optical networks.

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Design and Implementation of Multi-Stage Chaotic Ring Oscillator Based Random Number Generator in 45nm CMOS Process

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The True Random Number Generator (TRNG) circuits occupy a vital role in hardware security. Traditional Ring Oscillator (RO) based TRNGs works by amplifying thermal noise and supply noise jitters. To improve randomness, conventional ring oscillator based TRNGs harvest random noise from more stages consuming large area and power. The traditional Chaotic Ring oscillator based random number Generator (CRNG) uses nonlinear elements which are straightforward to bring about chaotic behaviour. We propose a Multi-Stage Chaotic Ring oscillator based random number Generator (MCRNG) for CMOS implementation which uses nonlinear elements in CRNG multiple times, to achieve more chaotic behaviour. The proposed MCRNG passes tests for randomness and are immune to modeling attacks. However, the proposed CRNG also harvests a little physical noise which acts as a compounder over

chaos. The proposed CRNG circuit is small in area, scales well with technology, operates at low voltages and does not require any special manufacturing process. The output bit stream of the proposed CRNG implemented in a 45nm process is tested using the NIST test suite and it passed 11 tests.
Keywords: True Random Number Generator, Chaos, CMOS, Ring Oscillator.

Exceptional Activity Pattern Detection Application Using Smart Watch Acceleration Sensor

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Exceptional activity pattern means the user's different activity pattern compared with activity in ordinary days. Everybody has their own daily life habit so that exceptional activity pattern is reflected differently. Activity pattern that provides the bad influence to individual health can be recognized by detecting user's exceptional activity pattern. The appearance of new wearable device and many other products with sensors made collecting activity pattern data much easier. In this paper, detecting activity pattern is improved in the accuracy with 3-axis accelerometer installed in Moto360 comparing with smartphone GPS in current market. We develop a smartphone application that provides information of user's exceptional activity pattern using collected data from Moto360. We utilize HDFS (Hadoop Distributed File System) to save and process raw data collected from 3- axis accelerometer of Moto360.
Keywords: Chaos Data Analysis; Exceptional Activity; Smart Watch; Acceleration sensor; Internet of Things; Healthcare

Asymptotic Behaviour of the Nonlinear Dynamical System Governing a Thermosyphon Model

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Thermoyphons, in the engineering literature, is a device composed of a closed loop containing a fluid who motion is driven by several actions such as gravity and natural convection. Their dynamics are governing for a coupled differential nonlinear systems. In several previous work we show chaos in the fluid, even with a viscoelastic fluid. We study the

asymptotic behavior depending on the relevant parameters and it is obtained through an inertial manifold.
Keywords: Thermosyphon, Asymptotic behaviour, Inertial Manifold.

Effect of delayed feedback on thermoacoustic oscillations

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In the present investigation we report our experiments dealing with the effect of phase-shift feedback on chaotic thermoacoustic oscillations in a premixed flame Rijke burner---a fundamental configuration employed frequently in the study of thermoacoustic coupling, which is currently a pressing problem in engineering systems such as gas turbine combustors, furnaces and rocket engine combustors. The phenomenon of thermoacoustic coupling itself is yet another nonlinear feedback coupling phenomenon, which has only very recently been identified exhibit a wide spectrum of complex dynamics, including chaos. The ultimate aim of research in this field is to control thermoacoustic oscillations. That thermoacoustic coupling can exist as chaos and other nonlinear states have implications on existing control strategies. We show here that the commonly employed phase-shift control results in an additional complexity, and that the resulting state could correspond to different nonlinear oscillations depending on the phase-shift feedback parameters.

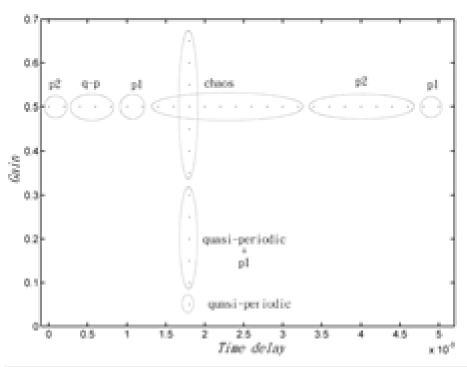

Figure: Varying the parameters of phase shift feedback results in a broad spectrum of dynamical states in the investigated thermoacoustic system.
Keywords: Thermoacoustic coupling, Combustors, phase-shift control, combustion control, Time-delay systems, Nonlinear time series analysis.

Coherence Resonance, Multifractality and Precursors in noise-induced dynamics of thermoacoustic coupling

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Thermoacoustic coupling is a nonlinear phenomenon involving time-delayed feedback coupling and affects practical systems such as gas turbine combustors, industrial boilers, furnaces and rocket engines. It was recently reported that noise-induced dynamics in a thermoacoustic system correspond to coherence resonance in nonlinear systems. This results in the observation of noise-driven oscillatory behavior prior to the subcritical Hopf bifurcation that is related to the onset of thermoacoustic coupling. Recently, there have also been several investigations on precursors to the onset of the instability and the their fractal characteristics. In this submission we will present an analysis of noise-driven oscillations prior to the onset of the instability with the motivation of connecting results on precursors to coherence resonance and to obtain further understanding of the stochastic dynamics of thermoacoustic coupling.

Keywords: Thermoacoustic coupling, Combustors, Power generation, Stochastic dynamics, Time-delay systems, Nonlinear time series analysis.

Reference:

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Stochastic Calculations in Nonlinear Vector Optical Systems

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Manakov equations as a versatile tool for modelling in nonlinear physics have recently addressed many challenges related to studying modulation and polarization instabilities, polarization properties of dissipative solitons, parametric and Raman amplifiers, etc. This type of equations can be obtained after averaging Maxwell’s equations over the fast randomly varying birefringence along the fibre length at the scale of the random birefringence correlation length. Using a direct stochastic simulation of coupled Manakov equations, we evaluate contribution of the stochastic antiresonance phenomenon into fibre Raman amplifier gain, gain fluctuations and pump-to-signal intensity noise transfer. Stochastic antiresonance is interpreted as an escape from metastable

trapping of polarization states accompanied by resonance like enhancement of fluctuations.

Keywords: Stochastic antiresonance, Manakov equations, Fibre Raman amplifier, Stochastic simulations.

Vector Stochastic Properties of A Fibre Raman Amplifier

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Direct numerical simulations of nonlinear vector light evolution in a Raman fibre amplifier with a random birefringence were performed in both Stokes and Jones representations. The Jones representation allows separating a stochastic part governed by material birefringence from a vector field dynamics governed by generalized vector nonlinear Schrödinger equation. The material part can be calculated independently from a system of stochastic ordinary differential equations and represented in the form of universal bibliotheca of stochastic coefficients for any type of dynamic vector partial differential equations. This approach demonstrated a resonance stochastization of the signal state of polarization within diapasons of the polarization mode dispersion parameter ≈0.02 ps/km1/2 and the fibre length ≈6 km. The effect can be interpreted as the simultaneous manifestation of stochastic anti-resonance and Raman nonlinearity, i.e. depletion of the pump by the signal with intra-fibre propagation. Pump-signal noise transfer is maximum near stochastic anti-resonance, but it does not vanish and can even grow with the decrease of the polarization mode dispersion. It was found, that the growth of signal power, i.e. enhancement of pump depletion, suppresses signal stochastization. Two multi-scale averaging analytical techniques were developed. They agree perfectly with numerical results in the limits of small and large propagation lengths as well as for arbitrary fibre length in the case of small polarization mode dispersions. The obtained results can be usable for both designs of a new generation of high-speed telecommunication systems and development of new multi-scale averaging mathematical techniques.

Keywords: Stochastic modelling, Multi-scale averaging techniques, Vector Raman amplification, Stochastic anti-resonance, Pump-signal noise transfer.

Nonlinear Analysis by Using Artifical Neural Networks of Radon Gas (^{222}Rn) Time Series in Kozan, Adana and Osmaniye Regions

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The artificial neural network (ANN) approximation is a non-linear black box model. This approach can useful alternative for modelling the complex suspended radon gas (^{222}Rn) time series. The ANN practice was used for time series predict, which it is a useful for such an earthquake prediction studies. The applied traditional model applications are building insufficient. Due to, the characteristic behaviours of the time series of direct runoff coefficients are very mixed. On account of, figure out the formation of seismic activity it is highly important to record the continuous measurements of the soil radon gas (^{222}Rn). Chaotic time series analyses methods provides a structured explanation for irregular behaviour of ^{222}Rn and gas anomalies in systems that are not stochastic. Lyapunov exponents' method is used to indicate the existence of chaos time series. Application of methodologies is achieved for Kozan, Adana and Osmaniye Regions, Turkey, where it is seismically very active.
Keywords: Chaos, Nonlinear time series analyses, ^{222}Rn, Artificial Neural Network (ANN).

Interfacial Instability of Multi-Phase Flow on a Non-Inertial Frame

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Multi-phase flow between rotating disks leads to patterns that depend strongly on disk geometry and the material lining the disks. Typically, one of the disks is smooth with periodic waviness, and the other is covered by rough, porous media with asymmetric grooves. A viscous fluid is introduced axially at the center of the annuli, thus there is a net flow in the radial direction. The system is exposed to the atmosphere, therefore at high rotational speeds, air is entrained in the gap between the disks. In a pack with multiple disks, there is also a random movement of the disks in the axial direction, thus the gap between any two disks is a stochastic variable. Finally, when an external force is applied to the system, the fluid is squeezed out of the gap resulting in solid contact. This leads to rapid temperature rise, the porous media on the disk surface are deformed, squeezing more fluid out of the gap, and the disks become engaged. The reverse process takes place when the disks are released, returning to the original chaotic open state.
During the process of alternating states, i.e. open, engagement, release, the flow remains laminar. However, at high rotational speeds, uneven pressure distribution is created in the grooves of the porous material, which results in flow reversal at the boundaries, and air entrainment.

Because the gap between the disks changes at a time scale much smaller than the engagement-release cycle, a chaotic formation and collapse of air bubbles occurs. Bubbles may be forming in one pair of disks while collapsing in another, and the flow is characterized by complete disorder. Gravity also plays a significant role, as fluid jets exiting the grooves are deflected. This results in submergence of the lower groves while the higher ones are exposed to atmospheric pressure. Inevitably, due to the high speed of rotation, all grooves are exposed to a periodic submergence at yet another time scale.
The foregoing complex flow conditions are studied by a multi-physics model that attempts to simulate the individual phenomena that take place during the engagement-release cycle. Visualization tests were also performed along with direct drag measurements. Although it is possible to validate the timed-averaged results of the model, it is difficult to produce repeatable simulations. Use of multiple rotating frames, leads to instability of the air-oil interface, and the model fails to converge. This behavior is erratic, and appears to be a consequence of the numerical approximation, as convergence improves with increasing resolution. However, the instability remains even at the highest resolution presently possible. No instability is noticed in single-phase flow, thus the problem is thought to be a result of the chaotic formation of air bubbles in the ever changing gap between the rotating disks.
Keywords: Numerical modeling, Laminar flow, Rotating disks, Bubble formation.

2-D and 3-D Solvable Chaos Maps

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It is presented that one-dimensional (1-D) chaos solutions give 1-D and 2-D solvable chaos maps, which are related to the Smith map and the Rogers map. Next, from 2-D general chaos solutions, a most general 2-D solvable chaos map is derived, and is shown to relate to the Holmes map and the 2-D maps obtained by discretizing the Duffing equation and the Van der Pol equation, which are known to have strange attractors. Finally, continuous 3-D differential equations, such as the Lorenz system and the Rössler system are discretized, and the 3-D maps are discussed from the standpoint of a 3-D solvable chaos map constructed by general chaos solutions.
Keywords: Chaos map, Chaos solution, Smith map, Rogers map, Holmes map, Duffing equation, Van der Pol equation, Lorenz system, Rössler system.

Chaotic Time Series by Time-Discretization of Periodic Function and Its Application to Engineering

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It is shown firstly that chaotic time series are generated by discretizing continuous periodic functions, and the functions are obtained as chaos solutions to, such as the Chebyshev differential equation and the pendulum model equation with the Jacobi elliptic functions. Next, a numerical method for the proposed nonlinear expansion is explained in detail to analyze and/or to generate chaotic time series and 1/f fluctuation from time-discretized functions. Finally, noise analyzer, chaos function generator and chaos controller are briefly explained, as an application of the chaotic time series and the nonlinear expansion to engineering.
Keywords: Chaotic time series, Time-discretization, Chebyshev polynomials, Jacobi elliptic functions, Nonlinear expansion, Noise, Fluctuation, Application to engineering.

A Comparative Study on Experimental Realizations of Multiscroll Chaos Generators

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Multiscroll chaos generators exhibit richer dynamics than single-band and double-band chaotic attractors, and they have possible application fields such as broadband signal generators, CNN (Cellular Neural Networks) structures, secure communications and random number generators. Since first multiscroll model proposed by Suykens and Vandewalle using quasilinear function approach, multiscroll chaotic attractors have been widely studied. In these studies, various multiscroll structures have been developed by using different nonlinear functions other than quasilinear function. Among these functions, the most common one is a modified form of the three-segment PWL (piecewise linear) function used in Chua's circuit. By adding additional breakpoints to three-segment PWL function, CNN based n-double scroll chaotic generators, n-scroll chaotic generators and multispiral chaotic generators have been proposed. Multidirectional systems having 1-D (Directional), 2-D and 3-D structures are commonly based on step function and the most important feature of these structures is to increase the number of step in the nonlinear function to obtain multidirectional systems. Another function called trigonometric function, which allows increasing scroll number via parameter changes in the function, also draws attention to

produce multiscroll chaotic attractors. In addition to these methods, multiscroll chaotic attractors obtained by using other techniques like nonlinear transconductance method, hysteresis method, adjustable wave functions and switching control method are also reported in literature.
Multiscroll chaos generators have been mostly implemented by using analog circuit design techniques utilizing different analog ICs and discrete components. Analog realizations of multiscroll chaos generators require complex circuit networks depending on the scroll number. With reconfigurability and programmability features, FPAA (Field Programmable Analog Array) and FPGA (Field Programmable Gate Array) devices offer more flexible design and implementation possibilities for multiscroll chaos generators. The aim of this paper is to present a comprehensive study that deals with both FPAA and FPGA based design and implementations of various multiscroll chaos generators using different nonlinear functions. After testing of multiscroll structures via numerical analysis for determining parameter values, these models are implemented on FPGA and FPAA devices. Experimental results verify efficiency of analog and digital programmable design methods for multiscroll chaos generators. With respect to analog and digital design approaches, the effectiveness of multiscroll chaos generators designed on programmable devices is compared with each other and the other discrete hardware implementations.

Keywords: Multiscroll Chaos Generators, FPAA, FPGA, Hardware Implementation.

Chaos synchronization by resonance of multiple delay times

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Chaos synchronization may arise in networks of nonlinear units with delayed couplings. We study complete and sub-lattice synchronization generated by resonance of two large time delays with a specific ratio. As it is known for single delay networks, the number of synchronized sublattices is determined by the Greatest Common Divisor (GCD) of the network loops lengths. We demonstrate analytically the GCD condition in networks of iterated Bernouilli maps with multiple delay times and complement our analytic results by numerical phase diagrams, providing parameter regions showing omplete and sublattice synchronization by resonance for Tent and Bernouilli maps. We compare networks with the same GCD with single and multiple delays, and we investigate the sensitivity of the correlation to a detuning between the delays in a network of coupled Stuart-Landau oscillators. Moreover, the GCD condition also allows to detect time delay resonances leading to high correlations in non-synchronizable networks. Specifically, GCD-induced

resonances are observed both in a chaotic asymmetric network and in doubly connected rings of delay-coupled noisy linear oscillators.
M.Jimenez Martin, O. D'Huys, L. Lauerbach, E. Korutcheva and W. Kinzel,
submitted to Phys Rev E

The features of acoustic emission chaos at autowave solid-state chemical reactions

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With the help of nonlinear dynamics system and determined chaos theory tools the features of acoustic emission chaos were studied at autowave exothermal chemical reactions in mixtures of organic powders. These processes concern to solid-state combustion synthesis (organic self-propagating high-temperature synthesis).
Sources of sound waves at the reaction are processes of chaotic local motion of reactionary medium - thermal expansion and cracking of organic crystals, bubbles and pores appearance in reaction front and at formation of final product structure.
Spectrums of acoustic signals, their autocorrelation functions, attractors (Ruelle - Takens - Newhouse model) and their dimensional characteristics, Kolmogorov's entropy are calculated, etc.; dynamics of these parameters was investigated.
It has been shown that the named parameters of acoustic emission correlate both with the reaction peculiarities and with the structure of condensed products obtained.
That allows not only to study acoustic emission by itself as chaotic process, but also to use it for studying of solid-state combustion and specification of its useful products.
Keywords: chemical reaction chaos, non-linear dynamic systems, acoustic emission, Chaotic attractor, Chaotic dynamics, combustion mechanism, product structure

Large number of steady states for animal populations in spatially heterogeneous environments

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Identifying the steady states of a population is a key issue in theoretical ecology, that includes the study of spatially heterogeneous populations.

There are several examples of real ecosystems in patchy environments where the habitats are heterogeneous in their local density dependence. We investigate a multi-patch model of a single species with spatial dispersal, where the growth of the local population is logistic in some localities (negative density dependence) while other patches exhibit a strong Allee effect (positive density dependence). When the local dynamics is logistic in each patch and the habitats are interconnected by dispersal then the total population has only the extinction steady state and a componentwise positive equilibrium, corresponding to persistence in each patch. We show that animal populations in patchy environments can have a large number of steady states if local density dependence varies over the locations. It is demonstrated that, depending on the network topology of migration routes between the patches, the interaction of spatial dispersal and local density dependence can create a variety of coexisting stable positive equilibria. We give a detailed description of the multiple ways dispersal can rescue local populations from extinction.

Keywords: Patch-model; Allee effect; Population migration; ODE

Diagnosis of Dynamic Regimes of Chaotic Systems by Methods of Topological Data Analysis (TDA)

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A well-known technique of the reconstruction of phase space from time series is based on the Takens' embedding theorem. It requires for the so-called Credo of a Perfect Experimenter to be met. In most practical cases, one has to either trust it or accept that it is invalid. The reconstruction of topology from time series, on the other hand, does not require such limiting prerequisites. The pioneering paper with the same title (Topology from Time series, Muldoon et al. Physica D., 1993, V.65, 1) was published 10 years after the first publication on embedology. However, the fast algorithms for computation of the Betti numbers of large simplicial complexes, built by embedding, have appeared only recently. For their successful application we have to explore the diagnostic capabilities of the TDA for the simple dynamic systems and random processes. We present some results of the TDA applied to random series with different correlation structures. After that, we illustrate the potential of the TDA to determine the dynamic regimes of the local Sun's magnetic fields, neurophysiology of the brain and paleoclimatology.

Keywords: Chaotic modeling, Topological Data Analysis, Deterministic chaos, Chaotic simulation.

Coherent Families: Spectral Theory for Transfer Operators in Continuous Time

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The decomposition of the state space of a dynamical system into metastable or almost-invariant sets is important for understanding macroscopic behavior. This concept is well understood for autonomous dynamical systems, and has recently been generalized to non-autonomous systems via the notion of coherent sets. We elaborate here on the theory of coherent sets in continuous time for periodically-driven flows and describe a numerical method to find families of coherent sets without trajectory integration.

Cardiorespiratory System with Strong Interaction

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A cardiorespiratory system with a strong internal interaction was studied when a respiratory tract was modeled as a self-oscillating system under an impulsive influence of heartbeats. The internal interaction gives rise to chaotic steady-state regimes. Analysis of bifurcation curves of the largest Lyapunov exponent, projections of phase portraits, temporal realizations and power spectrums showed the basic laws of dynamics of the cardiorespiratory system. The chaotic dynamics of heartbeat and respiratory systems are in good correspondence with an experimental information of healthy man.
Keywords: cardiorespiratory system, heartbeats, chaotic steady-state regimes.

THE PROCEDURE OF THE SYNTHESIS OF AUTOMATIC CONTROL OF THE AIRCRAFT CARRIER OF AEROSPACE COMPLEX WITH STRAPDOWN INERTIAL NAVIGATION SYSTEM (SINS)

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There is proposed the procedure of the synthesis of the automatic control of the aircraft carrier of aerospace complex with strapdown inertial navigation system (SINS).
The procedure involves several tasks:
1) Navigation problem is solved in a narrow sense. Coordinates of the current position of the object control are identified by using SINS.
2) Basic control laws u(t) are synthesized by taking into account the information, received from the SINS. Basic control laws u(t) are providing achievement of predetermined purpose objectives.
3) For SINS errors compensation and suppression of external disturbances is designed the dynamic controller with asymptotic observer.
Method of analytical designing of aggregated regulators (ADAR) is chosen as method of synthesis. The task is implemented in software «Maple» and «MATLAB/Simulink». While computer modeling control laws provides achievement of predetermined purpose objectives, evaluation of SINS errors and suppression of immeasurable external disturbances. In such a manner, there is demonstrated the working capacity of the synthesized system.
Keywords: aerospace complex, method ADAR, strapdown inertial navigation system.

Derivation of the generalized nonlinear Schrödinger equation of cosmogonical body formation and its application in exoplanet investigation

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This work considers the statistical theory of gravitating spheroidal bodies to derive and develop a new generalized nonlinear Schrödinger equation of a gravitating cosmogonical body formation. Previously, the statistical theory for a cosmogonical body forming (so-called spheroidal body with fuzzy boundaries) has been proposed. As shown in this work, interactions of oscillating particles inside a spheroidal body lead to a gravitational condensation increasing with the time. In this connection, the notions of an antidiffusion mass flow density as well as an antidiffusion particle velocity in a spheroidal body are introduced. The equations for calculating the partial derivative of the antidiffusion velocity (in the cases of absence or presence of an ordinary hydrodynamic velocity) as well as the complete derivative of the common (hydrodynamic plus antidiffusion) velocity with respect to the time are obtained. As shown here, these equations are more general than the analogous equations derived in Nelson' stochastic mechanics and

Nottale's scale relativistic theory. They are used for the derivation of the generalized nonlinear time-dependent Schrödinger equation describing a gravitational formation of a cosmogonical body. This work considers different dynamical states of a gravitating spheroidal body and respective forms of the generalized nonlinear time-dependent Schrödinger equation including the virial mechanical equilibrium, the quasi-equilibrium and the gravitational instability cases. Besides, the last case involves the avalanche gravitational compression increasing (when the parameter of gravitational condensation grows exponentially with the time) among them the case of unlimited gravitational compression leading to a collapse of a spheroidal body.
Accordingly oscillating interactions of particles a frequency interpretation of the gravitational potential and the gravitational strength of a forming spheroidal body is considered in detail. In particular, we explain how Alfvén–Arrhenius's oscillating force modifies the forms of planetary orbits within the framework of the statistical theory of gravitating spheroidal bodies. We find that temporal deviation of the gravitational compression function of a spherically symmetric cosmogonical body induces the Alfvén–Arrhenius additional periodic force. An oscillating behavior of the derivative of the gravitational compression function implies the special case when the additional periodic force becomes counterbalance to the gravitational force thus realizing the principle of an anchoring mechanism in exoplanetary systems.
Keywords: molecular clouds; initial oscillating interactions; slow-flowing gravitational condensation; antidiffusion velocity; generalized nonlinear Schrödinger equation; orbital oscillations

Dynamical Complexity Induced by Frequencydependent Optical Feedback in Dual-section Passive Mode-locked Quantum-dash Laser at ~ 1.55 μm

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Quantum nanostructure-based mode-locked (ML) dual-section semiconductor lasers have received much attention in recent years due to potential applications highspeed optical telecommunications and clocking. Particularly, passively mode-locked lasers subject to optical feedback or optical injection possess a rich diversity of dynamical regimes including lasing wavelength bistability, dropout dynamics and dark pulses due to their broadband gain and fast carrier dynamics. These processes are characterized by a large number of quite different

characteristic time scales, which determine the quality of mode-locked pulses and the dynamical behavior of the laser in general. Instabilities need to be identified and studied, with a uses to their suppression and exploitation in telecommunication networks.
In this work, we present experimental studies of complex nonlinear dynamics in modelocked-quantum dash lasers subject to frequency dependent optical feedback with fixed filtering. Filtered or dispressive optical feedback offers advantages over conventional optical feedback as its provides specific controllable spectral content of feedback to manipulate the laser dynamics, specifically by varying the filter bandwidth and detuning from the free running mode-locked frequency without introducing attenuating optics in the feedback loop. In addition, we discuss how the various dynamical regimes of modelocked laser with filter optical feedback depend on the filter bandwidth and frequency and also how the presence of particular dynamical state can induce a significant change in the timing jitter of a mode-locked regime. We suggest that the dynamics are manipulated and controled by changes in phase-amplitude coupling and thus strong carrier dependency of the index in the presence of frequency on the optical feedback.
Physically, when the free running mode-locking frequency is blue side of the filter frequency then the feedback induced red-shift in frequency with phase-amplitude coupling factor α. Our technique provides a simple and low cost way to effectively control mode-locked laser diode.
Keywords: Optical choas and dynamical Instability, delayed optical feedback, Nonlinear dynamics and bifurcation, Mode-locking, Quantum-Dash Semiconductor lasers.

ON THE SPACE OF TRANSITIVE MAPS

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A detailed literature is available for the study of transitive maps in topological spaces, especially in intervals. In this paper, a study of the space of transitive maps is expected. By looking at this space we can study chaotic functions on the space.
Keywords: Transitive maps, dense orbit, Devaney Chaotic.

Symbolic chaotic dynamics in radio communication systems

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Recently continuing intense theoretical and experimental research related to the use of deterministic chaos in modern communication systems. Particular attention in many works is paid to such interesting property of dynamical chaos, as the symbolic chaotic dynamics that makes it possible to divide the phase space of the system and implement a secure transmission of digital information. This paper presents the results of experimental and computational studies of chaotic secure radio communication systems, the operation of which laid the symbolic dynamics. Analysis of the results suggests the prospects of the proposed approach to protect information both in analog and digital communication systems.
Key words: Deterministic chaos, symbolic chaotic dynamics, radio communication systems.

Verification of the dynamical properties of a bouncing ball model

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The main aim of the paper is to research dynamic properties of the mechanical systems consisting of a ball, that is jumping between a baseplate and an upper plate. The model is constructed with one degree of freedom in the mechanical oscillating part. The system of movement is derived by ordinary differential equations. As the main result it is shown that the systems is showing regular, irregular and chaotic pattern for suitable choice of parameters using standard methods.
Keywords
Mechanical system; bifurcation; regular motion; chaos

Discrete dynamical systems with infinite Lyapunov exponent and their applications in computer science

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In recent decades, chaotic maps have found a lot of applications, including chaos based cryptography or pseudo-random number generation. Despite the many useful features, often the chaotic maps are marked by a close to 0 absolute value of the Lyapunov exponent. This may cause that the range of values of the control parameter for chaos is too small (as in the case of the logistic map). Furthermore, with the change of the control parameter value, chaos often disappears in favor of periodic solutions. This exposes cryptographic algorithms for efficient brute force. It is therefore necessary to seek and apply maps with large

Lyapunov exponent values, e.g. those that can give (theoretically) infinite value of the exponent. An example of such map is the so called Weierstrass recursion, which was presented in [1] and further analyzed in [2].
The aim of this study is to present this type of recursions and discuss their applications. Example of such chaotic map is the fallowing Riemann recursion with parameter a :

$$x_{k+1} = \sum_{i=1}^{n} \frac{1}{i^2} \sin(a i^2 x_k)$$

Figure 1 shows the Lyapunov exponent value λ of this recursion. It can be seen, that with the increase of the value a , λ , also increases. For $n \to \infty$, λ is increasing indefinitely.

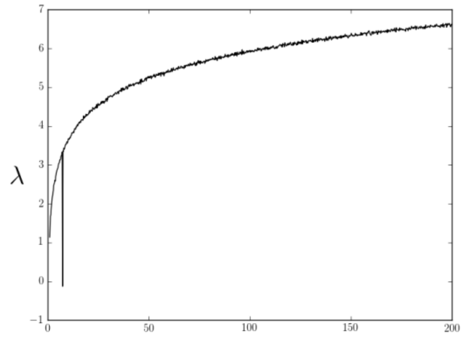

Fig.1. Lyapunov exponent of the Riemann recursion for $n = 100$.

Keywords: Discrete dynamical system, Lyapunov exponent, Riemann function, Chaos based cryptography.

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Various unfolding behaviour of proteinaceous materials depending on loading stiffness conditions

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Mechanical manipulation of proteinaceous materials is crucial for the biological unfolding behavior. Specifically, computational simulations enable us to understand the folding pathway and their behavior in detail. Previous computational manipulation study effectively reported that the unfolding characteristics of ubiquitin protein is different along to loading device effect using Brownian Dynamics methods. However, there are lack of knowledge about different unfolding behavior of ubiquitin proteinaceous materials in all-atom molecular dynamics (MD) and explicit solvent conditions. Here, in this presentation, we report the different mechanical unfolding behavior of ubiquitin materials using all-atom MD and explicit solvent conditions. Furthermore, by applying the different loading device effect in all-atom and explicit solvent conditions on ubiquitin, we precisely present the different unfolding behavior compared to previous unfolding simulation study applied with Brownian Dynamics methods. Our study shed lights on unfolding behavior under explicit conditions depending different loading device effects in detail.
Keywords: Protein reaction, Molecular Dynamics, Steered Molecular Dynamics, Brownian motions, and Different loading stiffness

Controllability of the Semilinear Heat Equation with Impulses and Delays on the State

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For many control systems in real life, impulses and delays are intrinsic properties that do not modify their controllability. So we conjecture that under certain conditions the abrupt changes and delays as perturbations of a system do not modify certain properties such as controllability. In this regard, in this paper we prove the interior approximate controllability of the Semilinear Heat Equation with Impulses and Delays.

Architecture of chaotic attractors for flows in the absence of any singular point

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Few chaotic attractors produced by three-dimensional dynamical systems without any singular point have now been identified but explaining how they are structured in the state space remains an open question. We here propose — in the particular case of the Wei system — to explain such a structure using one-dimensional sets obtained by vanishing two of the three derivatives of the flow. The neighborhoods of these sets are made of points which are characterized by the eigenvalues of a 2×2 matrix describing the stability of flow in a subspace orthogonal to it. We thus show that the attractor is spiralling and twisted in the neighborhood of one-dimensional sets where points are characterized by a pair of complex conjugated eigenvalues.

Global modelling from unstable periodic orbits: Feasibility and the influence of the data on model quality

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Global modelling is a powerful procedure to build mathematical models that reproduce the dynamics underlying the data. In this paper global models in the form of differential and difference equations are considered. The influence of the recorded variable on the estimated models was pointed out over a decade ago. In this paper the effect of the data content in terms of periodic orbits is investigated by estimating global models from a single unstable periodic orbit at a time. Numerical evidence shows that it is possible to estimate a chaotic global model that reproduces the whole attractor from a single periodic orbit. The results discussed in the paper also show that the quality of the final model not only depends on the observable but also on certain features of the periodic orbits used.

Experimental demonstration of photonic random bit generator by sampling laser chaos in the optical domain

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Secure and reliable random number (key) has an important application in secure communication field. Chaotic laser with the high bandwidth and the large amplitude random fluctuation is an ideal entropy source for

building the safe and reliable random number generator with high-speeds and thus receives great attentions. In 2008, A. Uchida et al. use chaotic laser and electronic 1-bit ADC quantization technique and realize a real-time 1.7 Gb/ s physical random sequence generator. In 2013, our group succeeds in constructing a real-time rate of 4.5 Gb/s physical random number generator. employing the electronic 1-bit quantization technique. In recent years, there have been many other researches that use electronic multi-bit ADC extraction technology to obtain physical random numbers with higher rates. However, the extraction of their super high speed physical random numbers is realized by using high speed oscillosco! pes to storage chaotic signal waveform and then offline process these data using algorithm such as shift register or high order difference, so these rate are just a theoretical expectation through multiplying the sampling rate and the final remained least significant bit (LSB) and have not been actually produced. In fact, the generation rate of 4.5 Gb/s is currently the fastest real-time rate in the reported literatures. To improve the real-time rate of the physical random number, it is bound to face the limitation of the electronic bottleneck.

All-optical physical random number generators can effectively overcome the limitations mentioned above. In 2010, our research group first proposed to utilize the wideband chaotic entropy source, all-optical sampler and all-optical comparator to implement the high-speed all-optical physical random number generator and numerically demonstrate the feasibility of real-time production for 10 Gb/s all-optical physical random number. But until now, there is no experimental realization about all-optical physical random number generators.

The implementation of high-speed and real-time all-optical sampling of chaotic light signal is the physical basis for the realization of all-optical physical random number generator based on chaotic laser. In this paper, we execute a principle experimental demonstration for the feasibility all-optical sampling of chaotic light signal through constructing a TOAD all-optical sampler and generating chaotic laser signal using an optical feedback semiconductor laser and complete a 5 GSa/s real-time and high-fidelity all-optical sampling to a chaotic laser with a bandwidth of 6.4 GHz from the optical feedback semiconductor laser. Further studies show that whether the optical sampling period is proportional to the the external cavity feedback time or not has a great effect on the weak periodic suppression of the chaotic signal. When both of them are out of proportion, the weak periodicity of the original chaotic signal can be effectively eliminated, facilitating the generation of h! igh-quality physical random numbers.

Existence and stability of coexistence states for a Lotka-Volterra competition model

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In this paper, we study the existence and stability of coexistence states with spatial heterogeneity of the environment in the classical Lotka-Volterra competition model. In particular, the two species are assumed that they have different distribution of resources, different intraspecific competition rates and different interspecific competition rates. However, we find that for small $ \tau $, the dynamics and coexistence states of system are determined by four scalar functions of $\mu \in (0,\infty) $. Our mathematical approach is based on Lyapunov-Schmidt reduction technique, implicit function theory and the perturbation theory.
Keywords: Spatial heterogeneity, Lyapunov-Schmidt reduction, Stability

Non-relativistic and relativistic ensemble predictions for the motion of a low-speed weak-gravity system

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The position and velocity expectation values and corresponding uncertainties predicted by non-relativistic mechanics for a low-speed weak-gravity nonlinear system – the bouncing ball – are compared with the general-relativistic predictions calculated using the same system parameters and initial Gaussian ensemble of trajectories. The expectation values of the ball's position and velocity are given by the ensemble means, and the corresponding uncertainties are given by the ensemble standard deviations. We show, contrary to conventional expectation, that the relativistic predictions are not always well approximated by the non-relativistic predictions. The size of the initial uncertainties plays a crucial role in determining whether the agreement will break down.

QUANTIZATION OF ELLIPTICAL STADIUM BILLIARD

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The Elipitical Stadium Billiard (ESB) is composed by two half-ellipses (major axis $2a$ and minor axis $2b$) that bracket a rectangular sector

of thickness $2t$ and height $2b$. As usual, we set $b=1$ [1]. Here, we consider the dynamics of the ESB in the vicinity of a particular line in the paramater space $a times t$, namely $t_c=t_0(a)=sqrt{a^2-1}$, with $1<a<sqrt{4/3}$.
If $t<t_c$, the billiard exhibits a mixed phase space. For $t>t_c$, there are numerical evidences od a critical transition tp fully developed chaos [1], [2].
The quantum counterpart of a given billiard corresponds to a 2D infinite quantum well with the same geometry. One has to solve the Helmholtz equation $(nabla^2+k^2)phi=0$, where phi is the energy eigenfunction and $k^2=2mE/hslash^2$, where E is the energy eigenvalue.
For the quantization of the ESB, we are using a boundary method [3] to obtain numerically the first 150,000 energy eigenvalues with great efficiency. To avoid degenerencies, our calculations are performed in a quartered billiard. Spectra are statistically characterized through the nearest neighbor spacing distribution, $p(s)$. We set $a=1.04$, as in [2], and obtain a spectrum for a numbers of values of t.
For $t=0$, the billiard is an ellipse (integrable) and $p(s)$ follows a Poisson distribution, as expected. By increasing t, the observed statistics are intermediate between Poisson and GOE. It is shown that the Brody distribution fits satisfactorily all considered stadia. In Addition we present eingenfunctions which exhibit scars of classical pantographic orbits.
Keywords: Elliptical Stadium Billiard, Mixed Phase Space, Quantum Chaos, Energy eigenvalues, GOE distribution, Brody distribution, boundary method.
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Divergent fluctuations of Lyapunov exponents in Hamiltonian lattices

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Finite-time Lyapunov exponents of generic chaotic dynamical systems fluctuate in time. These fluctuations are due to the different degree of stability across the accessible phase space. We show that the diffusion

coefficient D of the Lyapunov exponents (LEs) exhibits a nontrivial scaling behavior, D(L) ~ L^y , with the system size L. Here, we show that the wandering exponent y can be expressed in terms of the roughening exponents associated with universality classes of nonequilibrium surface growth. One of the most remarkable results is the divergence of the LE fluctuation (y >0) in systems with conserved energy, while (y<0) for dissipative systems and its universal.
Our theoretical predictions are supported by the numerical analysis of several spatially extended systems.

Gas-like Economic Models: from Exponential to Power-Law Distributions

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In this communication, the obtention of the exponential distribution in an statistical economic system as a consequence of the geometry and the equiprobability hypothese is shown. Equivalently, an operator governing the discrete time evolution of the wealth distribution of an out-of-equilibrium economic gas-like system is recalled. This operator is a nonlinear map in the space of wealth distributions, which is shown to conserve the total and mean wealth of the economic system. Moreover, it displays the exponential distribution as an asymptotic equilibrium. This can also be seen as a Boltzmann-like model, where an H.theorem is verified. Finally, a modified model, which breaks the local but not the global conservation of money in the system, just as a some kind of naif bank system, is shown to drive the system from an exponential to a power-like distribution with divergent moments. (This work was made in collaboration with Y. Pomeau: Springer PROMS 112, Ch.1, 1-12, 2015).
Keywords: Decay to equilibrium, Gas-like economic models, Equiprobability hypothese, Nonlinear modeling, Divergent moments.

Stochastic Process with Chaotic Dynamics: Human Complex Behaviour in Multi-Factorial Decision-Making

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Human decision-making is affected by many factors, rational and irrational ones. In particular, it can endow human behavior in learning

and adaptation to unknown environments with complex properties being anomalous for the inanimate world.

In the present work we analyze complex dynamics of a single agent imitating human adaptation to unknown environment under effects of novelty seeking. In the conventional models used in the non-equilibrium game theory the learning agents are assumed to act rationally in achieving the ultimate goal in order to maximize the cumulative reward gained during the learning. Such models lead to complex phenomena only in case of multiple interacting agents, while the single agent adaptation has been generally presumed to be trivial up to now.

We challenge this approach by endowing the learning agent with two interacting processing channels: the standard reward-based learning and a channel associated with the agent’s attraction to novel actions. We confine our scope to the case of the single agent adaptation and demonstrate that novelty seeking may lead to highly irregular long-terms processes in the learning dynamics when the intermediate levels of novelty seeking cause the choice probability distribution to oscillate and the number of the choice alternatives is three or larger. Two-mode system was studied previously [1].

Our results demonstrate that accounting for more mental complexity of the human evaluation of his/her actions greatly extends the spectrum of dynamical behaviors captured by the reinforcement learning model and can enable the basic explanation of transitions between these behaviors depending on the parameters. Moreover, as demonstrated numerically, when the number of choice alternatives exceeds two the system dynamics can be highly complicated, even really chaotic.

Finally we put forward for discussion a new type of stochastic processes that can be categorized as stochastic processes with nonlinear chaotic dynamics of the probability function. Human cognition endows this probability with individual causal power, which enables such nonlinear effects to come into being. This probability function can be governed, e.g., by the nonlinear Fokker-Planck equation whose kinetic coefficients depend on the probability function itself, which is the cause of chaotic dynamics. Moreover, the given stochastic process gives rise to weak nose affecting the distribution function, the consequences of this affect are also in the focus of the present research.

Keywords: Stochastic processes, Chaotic dynamics, Human behavior, Reinforcement learning, Novelty seeking, Multichannel evaluation.

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Visualization of erratic heart rhythms after heart transplantation by network tools

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Directed networks are constructed based on the nocturnal Holter recording of the heart-transplant people many years after the surgery. The vertices are labeled by values of observed RR increments, the edges link consecutive increments, the edge width shows how often one RR increment occurs after the other one. Irregular patterns arising from the network visualization allow to detect, and then classify dynamics of RR-increments of individual patients, i.e., detect abnormal rhythms in a patient oriented way. The approach can also be used in revealing reinnervation of the allograft in a way which is attractive for the clinical usage.
Keywords: Complex networks, Time-series complexity, Heart rhythm dynamics, Heart rate variability, Arrhythmia

Beautiful geometries underlying oceanic nonlinear processes

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Finding order in the apparent chaos that seems to govern ocean motions is a formidable task which has drawn the attention of scientists and oceanographers all over the world for the last decades. The endeavour of describing how different tracers (heat, salt, chlorophyll, contaminants) are transported in the ocean has become a global challenge, and its understanding is of vital importance for predicting and assessing their impact on global climate change or the distribution of natural marine resources.
In this talk I will provide an overview of recently developed tools, the so called Lagrangian Descriptors, which display beautiful geometries highlighting the always changing dynamical skeleton of the ocean. I will illustrate applications of these objects to the operational management of coastal emergencies such as the sinking and subsequent fuel spill by the Oleg Naydenov fishing ship in the Gran Canaria coast, Spain in April 2015.

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Collective Motion in The Continents Formation

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Convection is ubitiquitous phenomenon in nature such as the islands motion due to mantle convection. In the present study, we observe the dynamics of rafts on the Rayleigh-Benard convection. A single raft motion shows at least three types of motion i.e. the linear, oscillatory, and random motions. The velocity of single particle fits with the Gaussian distribution function. While the multiple rafts case show more complex motion, including the possibility of collective motion. We show that there is an indication of collective motion of multiple rafts as one of the law of motion in the Rayleigh-Benard convection. We conclude that collective dynamics are strongly related with the island formation in the early stage of the Earth.
Keywords: Rayleigh-Benard convection, random motion, Gaussian distribution, single raft, multiple rafts, collective motion, island formation

Dynamical properties of traffic time series

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The main aim of the paper is focussed on analysis of dynamical properties of road traffic time series, that are discrete time real data. For the analysis we use well established methods as maximal Lyapunov exponent and 0-1 test for chaos. Lyapunov exponents are computed

using embedding dimensions and reconstruction delay, where positive values of Lyapunov exponents suggest presence of chaos in dynamical system. Then "0-1" test for chaos is used to further support our findings. Advantage of "0-1" test for chaos is that it does not need preprocessing of the time series prior to analysis. As a main result it will be shown that there are regular as well as irregular patterns in the real world traffic time series and their potential for prediction.
Keywords: Dynamical system, traffic time series, Lyapunov exponents, "0-1" test for chaos, chaos.

In vitro direct and in vivo indirect evidence for the existence of water monomers and the need of chaotic modeling to understand their role in life processes

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We present direct experimental Magnetic Resonance evidence for the existence of water monomers in vitro and indirect in vivo evidence for the formation of nascent mitochondrial water monomers and their rapid dissipation via exchange with the large amounts of water in the body of mice and larvae. Modest molecular modeling exists for the initial stage, but we believe a better understanding of the role of water in life processes could be obtained by chaotic modeling. We are thus seeking collaboration with experts in chaotic modeling, in order to initiate relevant theoretical research and design of further experimental work.
Keywords: Water monomers, life processes, chaotic modeling.

Cystoseira vs Turf Algae: Inter-Algal Competition via a Population Dynamics Model with Pack Behaviour

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The co-existence of the alga Cystoseira and microalgae forming the turf, or covering nude rock on a barren, is described through a simplified trophic web including the algae as three different species in competition for light, nutrients, soil availability. The choice is to write a space-implicit model of ordinary differential equations (ODE) describing the evolution of the portion of occupation of the considered environment of two algal population: of Cystoseira, C , and of turf algae, T.

The two occupations show different recruitment mechanisms. The gametes of turf microalgae are brought by sea currents and continuously raining on the sea bottom; hence the recruitment contribution of dT/dt is a constant flow independent on the turf populations. The propagules of Cystoseira can only travel a very short distance away from the mother alga; moreover, propagules falling within the canopy forest cannot root: Cystoseira rectuitment happens only slightly outside the border of the canopy forest, and its value must be rather proportional to the Cystoseira portion laying there. In a space-non-explicit model, this purely border effect leads to a recruitment term in dC/dt proportional to the square root of C.
The prescription of being a growing function of the square root of the occupation portion, mathematically the same as the pack behaviour of populations interacting only through their border, is applied to all the growth or decrease terms representing processes taking place just along the borders of populated areas (e.g., the Cystoseira consumption due to sea urchins, because these invertebrates only browse along the border of the canopy forest, or the expansion of turf algae living along the turf border). The model presented will be the base for future analytical and numerical work aiming at the characterization of possible equilibria of such ecosystem.
Keywords: Populazion modeling, Pack-behaviour, Concurrence, Three-stable systems.

On a nonlinear equation with partial derivatives disturbed by a viscoelastic factor

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In this presentation we are interested in the existence and uniqueness of a classical model similar to partial differential equation that occurs in quantum mechanics relativistic disturbed by a factor of viscoelasticity problem governed by Lamé operator. We denote by Ω an open subset of 〖R〗_,^n with regular boundary Γ. Let Q the cylinder 〖R〗_x^n × ℝt with Q = Ω ×]0,T[; T fini, Σ boundary of Q, The Lamé system define by μΔ + (λ+μ)∇div, f and u_0 (x), 〖u〗_1 (x) are functions. We look for the existence and uniqueness of a function u = u(x,t), x ∈ Ω, t ∈]0,T[, solution of the problem (P).
(P){ █((∂^2 u)/(∂t^2)-μΔu+(λ+μ)∇divu+∫_0^t▒〖g(t-s)Δu(s)ds+〗 |u|^(p-2) u=f(x,t) in "□" x]0,T[@u(x,t)=0 on "□" @u(x,0)=u_0 (x), x∈"□" @∂u/∂t (x,0) 〖=u〗_1 (x) x∈"□" @)┤
Keywords: Nonlinear, Priori Estimate, Uniqueness, Viscoelastic.

Complex Dynamics In Hybrid Totalistic Cellular Automata Rule 2 and 39

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This paper provides a symbolic dynamics perspective to hybrid totalistic cellular automata (HTCAs). Under the function of hybrid and totalistic mechanism, we demonstrate that HTCA(2,39) possesses rich and complex dynamics through computer simulations and empirical observations. Furthermore, for three types of glider behaviors, we prove HTCA(2,39) is chaotic in the sense of both Li-Yorke and Devaney in its three particular subsystems. Finally, it is worth mentioning that the method presented in this paper is also applicable to other HTCAs therein.
Keywords: Hybrid totalistic cellular automata, symbolic dynamics, chaos, topologically mixing, topological entropy, glider.

A Generalized Stability Theorem for Non-autonomous Bidirectional Discrete Systems with Application

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Chaos synchronization (CS) and chaos generalized synchronization (GS) are important both in theoretical researches and practical applications, particularly in chaotic cryptography. This study introduces the definition of generalized stability (GST) for non-autonomous bidirectional discrete system (NABDS), which is extensions for chaos GS for corresponding bidirectional discrete system [1], GST for non-autonomous discrete system [2], and GST for bidirectional discrete system [3]. A constructive GST theorem on such kind of NABDS is introduced, which gives a general representation for GST NABDS. Using the theorem, one can easily construct new chaos systems to make the system variables be in GST. Examples are presented to illustrate the effectiveness of the theoretical results. Numerical simulations verify the chaotic dynamics of such discrete systems. Using a 8-dimensional GST NABDS constructs a 12- dimensional GS system, and then designs a 212 word chaotic pseudorandom number generator (CPRNG). Using a FIPS 140 based 2d word pseudorandom sequence test suite [4] tests the pseudorandom performance of the CPRNG. The results show that the randomness performances of our CPRNG are promising. Using the CPRNG and an avalanche encrypts scheme [5] encrypts an RGB image. The results suggest that the CPRNG is able to generate the avalanche effects which are similar to those generated via ideal CPRNGs.

Keywords: Generalized stability, Bidirectional, Non-autonomous, Randomness test, Avalanche encryption

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Lagrangian and Eulerian coherent structures in complex fluids and plasmas

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In this talk we present numerical simulations of a two-dimensional incompressible flow in a crisis-like transition to hyperchaos. We construct bifurcation diagrams and detect nonattracting chaotic sets known as chaotic saddles, using a fixed frame of reference in Fourier space (i.e., an Eulerian approach). We characterize the chaotic mixing properties of the fluid by detecting Lagrangian coherent structures and demonstrate that, prior to the transition, chaotic saddles can be used to predict the enhanced complexity of the spatiotemporal patterns observed in the hyperchaotic regime. In addition, we will characterize coherent structures in three-dimensional simulations of magnetized Keplerian shear flows in a regime of on-off intermittency. We demonstrate that large-scale coherent structures are characterized by high degrees of Fourier amplitude-phase synchronization by computing the Shannon entropy of amplitudes and phases in the three-dimensional spectral space. Finally,

we will show the application of Lagrangian coherent structures and the Jensen-Shannon complexity-entropy technique to analyze numerical simulations of non-Newtonian flows in modelsof blood vessels.

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Self-organisation of stochastic oscillators in a predator-prey model

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A predator-prey model of dual populations with stochastic oscillators is presented. A linear cross-coupling between the two populations is introduced following the coupling between the motions of a Wilberforce pendulum in two dimensions: one in the longitudinal and the other in torsional plain. Within each population a Kuramoto type competition between the phases is assumed. Thus, the synchronization state of the whole system is controlled by these two types of competitions. The results of the numerical simulations show that by adding the linear cross-coupling interactions predator-prey oscillations between the two populations appear which results in self-regulation of the system by a transfer of synchrony between the two populations. The model represents several important features of the dynamical interplay between the drift wave and zonal flow turbulence in magnetically confined plasmas, and a novel interpretation of the coupled dynamics of drift wave-zonal flow turbulence using synchronization of stochastic oscillator is discussed.

Keywords: Stochastic oscillators, Lotka-Volterra, Synchronization, Self-organization, Simulation

Impulsive Synchronization between Chen-Lee Circuits for Chaos-based Secure Communications

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This paper deals with the impulsive synchronization between two electric circuits, which are based on the Chen-Lee chaotic system. Its purpose is the presentation of a realistic approach, which can constitute a real chaos communications system. Nodal analysis is performed, the result of which is a simplified chaotic Chen-Lee oscillator, that produces the same output as the conventional ones. The coupling of the oscillators is controlled by a single voltage-controlled switch, which is adjusted by a square wave function generator. The digital implementation of the circuit mentioned previously was accomplished through the use of the Multisim circuit design and simulation environment. The results of the simulations confirm the functionality of the proposed communication scheme. Finally, the synchronization diagrams and the conclusions that arise from them are listed, with respect to the variations in the period and the width of the impulses.
Keywords: Chaos Communications, Chen-Lee System, Impulsive Synchronization, Chaotic Oscillator.

Morse-Conley-Forman theory for combinatorial vector fields

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In late 90' R. Forman introduced the concept of a combinatorial vector field on a CW complex and presented a version of Morse theory for acyclic combinatorial vector fields. He also studied combinatorial vector fields without acyclicity assumption, introduced the concept of a chain recurrent set and proved Morse inequalities in this setting. In this talk we present the Morse-Conley theory for combinatorial vector fields and a certain generalization of combinatorial vector fields oriented on applications in sampled dynamics. In particular, we study Morse decompositions and Conley-Morse graph for such fields.

Freezing, accelerating and slowing directed currents in real time with superimposed driven lattices

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A remarkable observation about time driven lattice setups, i.e., particles in a lattice which is shaken by external time-dependent forces of zero mean, is that they can show directed transport for an ensemble of

particles, although there exists no net force. Such transport has been realized in a variety of setups leading to many intriguing effects and applications like on-site particle trapping, particle sorting and efficient velocity filters. We provide a generic scheme offering real time control of directed particle current using superimposed driven lattices. This scheme allows to accelerate, slowand freeze the transport on demand, by switching one of the lattices subsequently on and off. The underlying physical mechanism hinges on a systematic opening and closing of channels between transporting and non-transporting phase space structures upon switching, and exploits cantori structures which generate memory effects in the population of these structures. Our results should allow for real time control of cold thermal atomic ensembles in optical lattices, but might also be useful as a design principle for targeted delivery of molecules or colloids in optical devices.

Keywords: Driven lattices, Directed transport, Hamiltonian systems, Chaotic simulation.

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Nonlinear economic dynamics

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Nonlinear economic dynamics has been a research topic during the last 30 years. Complex behavior can emerge from quite simple economic structures. The analysis of economic models using now technical dynamical resources allow us to give a different approach to the knowledge of different situations modeled in these terms. Topics in this section are: bifurcation analysis, chaotic behavior, Lyapunov analysis, attractors,…, all of them applied to economic models.

Analyzing the existence of chaos in the Matsumoto-Nonaka duopoly

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A.Matsumoto (2006) introduced a two--market model consisting in two firms which produce differentiated goods. The first firm produces goods

x in the first market and the second firm produces goods y in the second market. It is assumed that externalities of different sign exist.
We study the number and the type of attractors.
In the case of this model, we exploit the fact that reaction maps have negative Schwarzian derivative and we analyze the existence of topological chaos.
Keywords: chaos; topological entropy; economic model

The Structure of Robust Chaos in Two-dimensional Discontinuous Piecewise Maps

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Many natural systems that occur in the real world can be described by piecewise maps. In a large number of practical situations, in electronic circuits, mechanical, engineering systems and economics, a piecewise map can represent a reasonable approximation of the original system. Some piecewise maps have been shown to display chaotic behavior, which has been extensively analyzed, often with an ultimate goal to control and use the chaos. The purpose of this study is to investigate the structure of robust chaos in two-dimensional discontinuous piecewise maps. Robust chaos is defined by the absence of periodic windows and of coexisting attractors in some neighborhood in the parameter space of a dynamical system. In recent years, it has been shown that robust chaos is controllable, and the problem of effectively generating it has been studied with a view to applications, such as in electrical engineering and economics. In this research, we use a piecewise linear normal form for two-dimensional piecewise discontinuous maps to determine regions of parameter space where a bifurcation leading to chaos might occur. We carefully prove the onset of these chaotic attractors, and show that they are robust to small parameter changes. The complicated structure of these attractors is revealed via analytical calculations of the limiting boundary crises within which the robust chaos is observed. Moreover, the mechanism by which robust chaos comes into existence is uncovered. The study shows the existence of unusual basins of attraction for some chaotic attractors; and we provide a strategy to determine the boundaries of such a basin of attraction. The results of these analytical procedures are applied to generate robust chaos.
Keywords Dyanmical Systems, Discontinuous Piecewise linear Maps, Robust Chaos, Border Collision Bifurcations

Mode selection and synchronization in weakly coupled semiconductor lasers

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Many systems in science and engineering can be described as networks of coupled dynamical systems. Understanding of how the individual systems' dynamics interact with the structure of the network through which they are coupled is fundamental in predicting or engineering their collective behavior. The master stability function makes it possible to find sufficient conditions for a set of coupled dynamical systems to synchronize given a coupling network topology. However, it is often the case that systems cannot meet the conditions for perfect synchronization, so it is useful to look for ways to allow for imperfect synchronization, such as cluster synchronization or partial synchronization. Here, we show a mechanism by which it is possible to induce robust, close to perfect synchronization in arrays of coupled semiconductor lasers with weak delayed coupling. This synchrony holds for both fixed-frequency continuous-wave solutions as well as for chaotic solutions. To understand and describe this process, we have developed an extension of master stability function theory.
Keywords: Coupled oscillators, Semiconductor lasers, Master stability function, Delay differential equations, Spatial modes.

Dynamical Heterogeneity and Aging in Turbulence with a Nambu-Goldstone Mode

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We investigate the Nikolaevskiy equation numerically using exponential time differencing method and pseudo spectral method. This equation develops a long-wavelength modulation that behaves as a Nambu–Goldstone mode, and short-wavelength instability, which exhibit turbulence. Using the autocorrelation of its fluctuations, the statistical properties of the turbulence governed by the equation are investigated. The autocorrelation then has been fitted with The Kohlrausch– Williams–Watts (KWW) expression. By varying the control parameter, we show a transition from compressed to stretched exponential for the autocorrelation function of Nikolaevskiy turbulence. The compressed

exponential is an indicator of the existence of dynamical heterogeneity while the stretched indicates aging process. Thereby, we revealed the existence of dynamical heterogeneity and aging in the turbulence governed by Nikolaevski! y equation.

Keywords: Compressed Exponential, Dynamical Heterogeneity, Nikolaevskiy equation, Streched exponential, Turbulence.

Seasonal dynamics of radio refractivity for selected locations in Nigeria using BDS Test

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This work focuses on the investigating chaos in surface radio refractivity over Nigeria using Brock-Dechert-Scheinkmen (BDS) test over twelve locations covering the different climatic zones of Nigeria. Atmospheric data spanning the space of eleven years (January 20004 to December 2014) was obtained from the ERA-INTERIM project. The radio refractivity of each location was calculated accordingly using respective formula. The computed radio refractivity time series were tested for chaos using the BDS statisics. The BDS statistics test can be applied to a series of refractivity values to check whether the refractivity is independently and identically distributed. It was observed that the BDS values in the rainy seasons was very low while that of the dry season was high that is above 1.96. Theses means that at dry season surface radio refractivity are in a state of chaos. These shows that the characteristics of radio refractivity in the troposphere as they relate to metrological parameter is of fundamental importance in planning and advancing radio waves propagation and wireless communication with the troposphere.

Keywords: BDS test, radio refractivity, troposphere, chaos

Study of Solar radiation dynamics using non-linear model

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In this study, we investigate the effect of daily air temperature and relative humidity on solar radiation using non-linear model over four

climatic zones in Nigeria. The chaotic dynamics of the solar radiation in terms of time series and phase portraits of attractors were also observed. The results of nonlinear parameter estimates of the model were statistically significant based on the values of coefficient of determination and root mean square errors. Therefore, this model is suitable for estimation of solar radiation data in the study location and determines the choaticity nature of climate system.

Keywords: Solar, Radiation, Chaotic, Nonliner, Model.

Lagrangian coherent structures in geophysical flows

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Lagrangian Coherent Structures (LCS) are key material surfaces that shape global transport. Thegeodesic LCS theory enables unified detection of all relevant LCS types in unsteady 2-d flows in a frame-independent manner. These are: hyperbolic LCS (generalized invariant manifolds ormaximally attracting/repelling material lines); elliptic LCS (generalized KAM tori or eddyboundaries); and parabolic LCS (generalized twistless KAM tori or jet-core barriers). In this talk I will review the basic elements of the theory and present results from several recent applications to oceanic flows which shed light into the nature of surface-ocean dispersion as well producedaccurate transport estimates and predicted sudden changes in the shape of pollutant distributions.

Work in collaboration with F. Beron-Vera, Y. Wang and G. Haller

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Influence of Frequency Excitation on Bifurcational Behaviour in an Experimental 2-DoF Mechanical System with Stick-Slip Friction

Paweł Olejnik, Wojciech Kunikowski, Jan Awrejcewicz

Influence of excitation frequency on the chaotic dynamics of a 2-DoF mechanical system is investigated. The analyzed system consists of a vibrating block on a transmission belt driven by a DC motor. Stick-slip frictional effects between the block and the belt introduce significant varying of load affecting the operation of the driving system. Resultant unsteady rotational velocity of the DC motor acts as a time varying excitation for the vibrating system. Behavior of the analyzed system was investigated and compared with its response to a periodic excitation. Mathematical models of the block-on-belt system with normal force intensification mechanism and a DC motor driving system with worm gear have been developed and virtualized. Some prescribed changes of the investigated model's parameters provided a bifurcation diagrams delivering some interesting results and conclusions.
Keywords: Stick-slip dynamics, Bifurcational analysis, Numerical simulations, Experimental measurements.

Presence of chaos im microscopic and macroscopic scale problems

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In this talk, we consider two different problems modelled by Hamiltonian systems with two degrees of freedom: the Restricted three-body problem (macroscopic scale) and the hydrogen atom in a circularly polarized microwave field (microscopic scale). We describe how the invariant manifolds of some particular periodic orbits are responsible for the presence of chaos.

Hyperchaos in a Simple Four Dimensional Sprott B system

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We present here a simple four dimensional (4-D) Sprott B system.This 4-D system has six terms with two quadratic and only one control parameter. The novel system has a line equilibrium with three zero eigenvalues which makes it totally different from existing simple 4-D systems. Its basic properties and uniqueness are analyzed using Lyapunov exponents spectrum, Lyapunov exponents dimension spectrum, bifurcation diagram, Poincare sections and phase portraits.

Keywords: Hyperchaos, Line equilibrium, Sprott Systems, Simple 4-D Sprott B System.

In short about some stochastic techniques useful in the systems analysis

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As it is known, when a differential equation is considered if it is allowed for some randomness in some of its coefficients, it will be often obtained a so-called stochastic differential equation which is a more realistic mathematical model of the considered situation.
On the other hand, the stochastic-approximation procedures require very little prior knowledge of the process and achive reasonably good results, and for this reason such methods work satisfactorily in various applications.
Now when we refer to chaos and chaotic and complex systems to describe the comportment of some natural phenomena it is very useful to consider phenomena of the type of a Brownian motion which is a more realistic model of such phenomena. In such a context appear to be naturally to talk about a passing from chaotic and complex systems to Brownian motion.
Thus, we shall refer, in short, to some aspects regarding the stochastic differential equations in connection with some aspects regarding models of the Brownian motion useful in various studies which involve chaotic systems. Some aspects regarding the Brownian motion in various dimensions are also discussed shortly.
Keywords: stochastic calculus, stochastic differential equations, Markov processes, Markov property, Brownian motion

A Novel S-box Algorithm Based on Chaotic Behavior of Soil Radon Gas

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Substitution boxes (S-boxes) are an important part of symmetric encryption systems. Since this structures is the only nonlinear part of a block cipher. Therefore, the S-box should be constructed such that, its nonlinearity is as high as possible. This paper discusses an efficient S-

box design based on continuous measurement of soil radon gas. The main contribution of this paper is proposed entropy source. Natural and geophysical observations are not usually regular and, these observations can be used as entropy source. Security evaluations of the proposed design strategy show that generator can provide high quality random bit sequences.

Keywords: Substitution boxes (S-boxes), entropy source, soil radon gas, computer application of natural and geophysical observations.

Amplified response in coupled chaotic oscillators by induced heterogeneity

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A phenomenon of emergent amplified response is reported in two unidirectionally coupled identical chaotic systems when heterogeneity as a parameter mismatch is introduced in a state of complete synchrony. The amplified response emerges from the interplay of heterogeneity and a type of cross-feedback coupling. It is reflected as an expansion of the response attractor in some directions in the state space of the coupled system. The synchronization manifold is simply rotated by the parameter detuning while its stability in the transverse direction is still maintained. The amplification factor is linearly related to the amount of parameter detuning. The phenomenon is elaborated with examples of the paradigmatic Lorenz system, the Shimizu-Morioka single-mode laser model, the Rössler system, and a Sprott system. Experimental evidence of the phenomenon is obtained in an electronic circuit. The method may provide an engineering tool for distortion-free amplification of chaotic signals.

Keywords: Chaos, coupled oscillators, synchronization, amplification, heterogeneity.

Bifurcation based parameter selection of PB model in DNA

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Recently, energy transport in nano-scale devices has been attracted many interests due to desire to achieve new sources of energy and on-chip cooling. Since first report on heat control, many efforts have been

done to consider thermal properties of various nano-devices to be used as thermal circuit ingredients. In the recent years, bio-materials such as DNA have been regarded as a fascinating nano-wires due to their special mechanical and self-assembly properties. Interestingly, DNA based nano-electronic devices and molecular motors have been constructed. So, considering the heat conduction properties of DNA seems to be important because of utilizing as functional devices. On the other hand, the selection of the potential parameters is a very important issue. In this paper, thermal conduction properties of various sequences based on Peyrard-Bishop model have been investigated. An approach has been proposed for exact tuning of potential parameters of DNA molecule based on Bifurcation analysis.
Keywords: Bifurcation analysis, Heat conduction, DNA, PB model, Parameter estimation

Emergence of limit cycles and their bifurcation in density wave oscillations for natural circulation loop

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The natural circulation loops are very simple structure for passive heat transfer in any system. Due to void generation and pressure loss, a different type of instabilities occurs in this system. Density wave oscillations are one of the major instabilities, which these loops encounter and that will affect the operational of the loops. Natural circulation loops have been implemented in water cooled nuclear reactor to make it safer. In boiling water reactor, heat generated in the core transferred to the coolant (i.e. water) which led to void generation. The density variations in the system lead to emergence of density wave oscillations in the system. The type I, II and III stability boundary have been drawn on the parameter planes and these boundaries are basically Hopf curves. Sub critical or super critical Hopf bifurcation occurs for the critical values of parameters and limit cycles are born dependin! g on type of Hopf bifurcation. Subcritical Hopf gives rise to unstable limit cycles whereas supercritical Hopf bifurcation gives rise to stable limit cycles. The emergence on limit cycles in this systems makes system non-linearly unstable and this is not desirable in case of nuclear reactors. The phase plane analysis and time history graph for the limit cycles in natural circulation loops has been drawn on parameter plane.
Keywords: Nuclear Reactor, Thermal Hydraulics, Limit cycles, Hopf Bifurcations, Density Wave Osicllations

A Study of Dynamics of the Tricomplex Polynomial η^p+c

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In this article, we give the exact interval of the cross section of the so-called Mandelbric set generated by the polynomial z^3+c where z and c are complex numbers. Following that result, we show that the Mandelbric defined on the hyperbolic numbers D is a square with its center at the origin. Moreover, we define the Multibrot sets generated by a polynomial of the form Q_{p,c}(η) =η^p+c (p∈N and p ≥ 2) for tricomplex numbers. More precisely, we prove that the tricomplex Mandelbric has four principal slices instead of eight principal 3D slices that arise for the case of the tricomplex Mandelbrot set. Finally, we prove that one of these four slices is an octahedron.

Interaction Studies of a Thermo-sensitive Polymer synthesized In-vitro on the Kinetics of Belousov-Zhabotinsky Reaction

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A thermosensitive polymer namely poly(N-isopropylacrylamide) was successfully synthesized in vitro and covalently bonded to ferroin as catalyst in the Belousov Zhabotinsky (BZ) reaction. The polymer has been confirmed from UV and FT-IR spectra. The lower critical solution temperature (LCST) of the polymer has been explored. The LCST has also been checked visually by turbidity measurements of the polymer at its lower critical solution temperature. Moreover, other phenomenon like effect of ionic strength by adding NaCl solution to the polymer has been studied. LCST of the polymer decreased on the addition of NaCl. The polymer synthesized has been treated as an additive in our optimized catechol-ferroin- $BrO3^-$, catechol - Mn(II) - $BrO3^-$ and catechol - Ce(IV) - $BrO3^-$ BZ systems. The results were expressive and distinguishable. Furthermore, interaction of ferroin based BZ system with polymer was also explored at elevated temperatures.
Keywords: Belousov-Zhabotinsky reaction, Catechol, Ferroin, LCST, Thermosensitive, Polymerization, Kinetics.

Spectral properties of a spinet billiard

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Firstly built by Giovanni Spinetti some five centuries ago in Venice, the spinet is a plucked string musical instrument activated from a keyboard, i.e., a smaller type of harpsichord. Here, we study the two-dimensional vibrational modes of the air volume enclosed in a wooden cavity with the geometry of the so called English bentside spinet. Solutions of the corresponding wave equation are numerically investigated. The calculated eigenfrequencies are shown to be in good agreement with the measured acoustic spectrum in a homemade spinet built by the first author. In addition, it is shown that both short-range (nearest neighbor spacing distribution) and long-range (Dyson-Mehta statistics) spectral correlations of a billiard with the spinet geometry are close to those exhibited by the eigenvalues of random matrices from the Gaussian Orthogonal Ensemble (GOE).
Keywords: Quantum chaos, quantum billiards, spinet, random matrices.

Bifurcation Patterns of Compensated DC-DC Converters with Delays

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This paper focuses on the investigation of effects of unavoidable delays in the control circuitry of switching DC-DC converters, proving that non-idealities of the feedback loop noticeably change the global dynamics, chaotization scenarios and bifurcation patterns of nonlinear circuits. Complete bifurcation diagrams are constructed for the current-mode controlled boost converter with compensation ramp and definite values of delays. The changes in the sequence of bifurcations and structures of chaotic regions introduced by interaction of effect of the compensation and delays are studied and explained in terms of complete bifurcation analysis.
Keywords: Bifurcations, Chaos, Non-smooth phenomena, Switching power converters

New Conception of Fractal Radio Device with Fractal Antennas and Fractal Detectors in the MIMO Systems

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The modern radio engineering is based on the classical theory of an integer measure and integer calculus. Over the whole period of radio development there has been a trend of the growth of the number of radio channels for increasing the volume and quality of information. Classical detectors and their mathematical supply have virtually reached its saturation and limit. A multiple-input-multiple-output (MIMO) system has a complex internal structure. The single response of the system is the result of the cooperative effect from different stimulus. In recent year a new direction of multichannel systems development has taken shape: the so-called fractal-frequency multiple-inputmultiple-output systems - the new idea of the author. Note that the main thing in such systems - the use of fractal antennas and fractal detectors. Fractal-frequency MIMO (FF MIMO) systems and their connection with another class of multichannel systemsmultisite systems – are considered in the work.
Keywords: Fractal, Scaling, Fractal-Frequency MIMO Systems, Fractal Radio-Systems, Fractal Radio-Elements, Fractal Radar, Detectors, Non-Markovian Process.

Frequency Coherence Function of a Radar Channel Forming Images of a Fractal Surface and Fractal Objects

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Optical and radio physical observation methods in the microwave band (from decimeter to millimeter waves) are widely used for solution of radar and remote sensing problems. Introduction of digital processing of space–time signals and digital control of the antenna aperture (antenna as a dynamic space–time filter) allows one to form and obtain radar images (RIs) of the terrain and objects. This solves the main radar problem: detection and recognition of objects in the presence of reflections from terrain and the radar internal noise. At present, there are many studies of wave interaction with fractal structures. Consideration for the frequency correlation of the modulated wave scattered by a statistical surface is of critical importance for estimation of the spectral width of complex sensing signals, frequency intervals in multifrequency radio systems and passbands of wideband signals, the frequency-averaged intensity of the wave field, shape distortions of sensing signals, the flight altitude, oceanographic characteristics, and the wave phase (the so-called phase problem). The objective of this study is to perform mathematical modeling of 2D anisotropic fractal surfaces and fractal objects, develop the theory of the frequency coherence function (FCF) of

a space–time radar channel for sensing and formation of radar images of a fractal surface and fractal objects, and analyze this function. Thus, the generalizations and new proposed solutions substantially extend the scope of problems of statistical wave diffraction theory.

Keywords: Fractal, Radar, Fractal Surface, Frequency Coherence Function, Radar Images, Mathematical Modeling.

Scaling of the Fractals Antennas

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Computer simulation is employed to simulate the electrodynamics parameters of new fractal antennas and frequency-selective surfaces based on such antennas. The analysis of the original fractal antennas is supplemented with the study of the fractal frequency-selective 3D media or fractal sandwiches (i.e., radio electronic fractal micro/nanostructures that contain no less than two layers. The efficiency of the fractal antennas and the fractal frequency-selective 3D media is demonstrated. The methods to create new passive electron components and elements for modern broadband and multifrequency radio systems based on such media are proposed. The fractal antennas make it possible to develop multiband variants with small dimensions and to optimize the technology of such devices. The advantage of the fractal antennas (monopoles and dipoles) lies in the fact that the resonance frequencies are less than the resonance frequencies of the classical (Euclidian) antennas with the same dimensions. The intrinsic broadband properties of the fractal antennas are perfect for intellectual applications, in particular, data protection. The fractal antennas can be used in modern telecommunications; broadband and nonlinear radars; the systems for the search for, localization, and tracing of mobile objects; position finding under complicated urban conditions, detection of unauthorized radio sources that can be used by terrorists; military communications; marking of various objects; space communications; modern physical experiments; etc.

Keywords: Fractal, Scaling, Antenna, Fractal Antenna, Fractal Electrodynamics, Fractal Radar, Fractal Radio Systems, Simulation.

Lagrangian simulation of transport in the ocean frontal areas

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A Lagrangian methodology is elaborated to simulate transport of water masses across ocean frontal zones. A large number of synthetic tracers are launched along a fixed zonal line somewhere to the south of a frontal boundary under study.
We compute a number of Lagrangian indicators of fluid parcels advected in a given velocity field. Locations and dates where and when the tracers cross a given latitude in the ocean frontal area are fixed. A complex of the numerical codes is compiled to compute and plot a number of diagrams illustrating different aspects of the cross frontal transport. This methodology is applied to the study case of transport of subtropical and subarctic waters across the thermal front in the Japan Sea which is a marginal sea communicated with the Pacific Ocean via shallow straits. The transport is studied numerically based on satellite altimeter data from 1993 to 2015.
We find typical pathways of subtropical and subarctic waters across the Subpolar Front. This transport is shown to be meridionally inhomogeneous with “gates and “barriers whose locations are defined by the local velocity field. There are some “forbidden” areas where the northward transport has not been found during all the observation period. The transport via the gates occurs by a portion-like manner due to specific dispositions of eddies along the Subpolar Front facilitating propagation of waters across the front.
Keywords: Transport, Ocean Front, Lagrangian Simulation, Japan Sea.

Build Of The Compound Chaotic Multiattractors With The Variable Composite Structure

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The way of building of compound chaotic multiattractors with the reconstructed composite structure defining a relative positioning of local chaotic attractors as a part of a multiattractor is presented.
Keywords: multiattractor, chaotic attractor, replication operator, dynamic system.

Construction of compound chaotic multiattractors containing the same type of local attractors with different parameters

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Presents a method for constructing a composite chaotic multiattractor that allows you to set the required difference between local chaotic attractors that are part of multiattractor
Keywords: heterogeneous multiattractor, compound multiattractor, chaotic attractor, replication operator, dynamic system.

Relation between the extended time-delayed feedback control algorithm and the method of harmonic oscillators

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In a recent paper [Phys. Rev. E 91, 012920 (2015)] Olyaei and Wu have proposed a new chaos control method in which a target periodic orbit is approximated by a system of harmonic oscillators. We consider an application of such a controller to single-input single-output systems in the limit of an infinite number of oscillators. By evaluating the transfer function in this limit, we show that this controller transforms into the known extended time-delayed feedback controller. This finding gives rise to an approximate finite-dimensional theory of the extended time-delayed feedback control algorithm, which provides a simple method for estimating the leading Floquet exponents of controlled orbits. Numerical demonstrations are presented for the chaotic Roessler, Duffing, and Lorenz systems as well as the normal form of the Hopf bifurcation.
Keywords: Control of chaos, Time-delayed feedback control algorithm, Method of harmonic oscillators, Floquet exponents.

Attenuation of Dissipative Device Involving Coupled Wave Scattering and Change in Material Property

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Numerous models are available for computing sound attenuation by dissipative silencers typically found in internal combustion engines. In most efficient approaches that demonstrate such type of silencers, only the structural borne mode propagates within each duct section. However various designs have found applications in a range of industries where both structural borne mode and fluid borne mode propagates to control

the noise. This study deals with the attenuation and performance of dissipative device like hybrid silencer involving coupled wave scattering for both structural as well as fluid borne mode incidents. Such wave structure for a dissipative device are considered in order to control noise under different circumstances. In particular device comprises inlet/outlet duct sections and a membrane attached internally to the outlet duct which may vary to tune the device. The hybrid mode matching technique is used to insight the physical situation. We report that how the power distribution in different sections of device is affected by attenuated regions of relative sections and material properties of the device. Moreover the fundamental property of the truncated system is verified through the conservation of power distribution between the fluid regions and the membrane.
Keywords: Acoustic, Attenuation, Propagation, Mode-matching, Power distribution.

Complexity of the S&P 500 Time Series from 2005 till 2015

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Stock market index S&P 500 time series, from 2005 till 2015 year, is considered.
We compute complexity Cmp, defined using permutation and linear combination, for subseries of length 110. Without knowledge about the rules producing time series, certain dependence of Cmp on possible value of the 110th point can be interpreted as certain traders behavior. There are four behavior types, related to the shapes of minima and maxima in the Cmp diagrams. In some cases the traders behavior is mainly under the rules, and in some cases their behavior is mainly opposite to rules. As the third type of the traders behavior, we find sometimes that rules are there, but traders behavior is not mainly under the rules nor opposite to rules. The fourth type of traders behavior is stochastic one - without rules. We found out that large changes of the index S&P 500 are preceded by stochastization. We can not forecast stock market crashes, but we can perceive stochasticity on time, as a dangerous stock market situation.
Fast computing with short time series is the advantage of our approach.
Keywords: Stock market index, Complexity, Time series

Quantum chaos in planar hydrogen like atom confined in time-dependent billiards

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Quantum dynamics of atoms and molecules subjected to spatial confinement is of importance for different problems contemporary nanoscale physics and technology. The main issue here is the role of nanoscale confinement in macroscopic properties such as heat capacity, conductance and dielectric properties. In this work we address the problem of quantum dynamics of a one-electron atom in time-dependent billiard with circular boundaries. Besides the size effects such system is potentially relevant to the problem of atom cooling using atom-optic billiards [1-3]. The latter can provide quantum billiards with time-varying walls. Finding effective and maximally tunable methods for cooling of atoms is a high priority problem in the physics of cold atoms and atom optics. One of the primary goals of this work is to study possibility for tunable atom cooling in time-dependent billiard geometries. Earlier, the atom in stationary billiards has been studied in few works on by solving the stationary Schrodinger equation for Coulomb potential with billiard boundary conditions. Unlike the textbook case of the bulk boundary conditions, the problem is usually solved numerically, by finding the eigenvalues of the system as the zeros of the wave functions at billiard walls. In this work we study classical and quantum dynamics of planar one-electron atom confined in static and time-dependent (breathing) billiards of different shapes. In particular, by solving time-dependent Schrodinger equation for Coulomb potential with time-dependent boundary conditions given in circular, elliptic and stadium shaped billiards. We explore possibility of atom cooling and acceleration in different regimes of the wall's motion. Using the obtained solution we compute the average kinetic energy as a function of time. It is found that by choosing proper wall's oscillation amplitude and frequency one can achieve the regimes when the average kinetic energy monotonically grows or decreases during long enough time period. The spectral statistics for corresponding static systems is also analyzed. The obtained results can used for atom cooling of atoms using atom-optic billiard traps. Besides the atom cooling, atom confined in time-dependent hard wall box is relevant to the problem of behavior of atoms and molecules under high pressure induced by billiard walls.

Keywords: Quantum chaos, Time-dependent billiards, Hydrogen like atom

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Liquid crystals for dynamic control of optical phase and wavefront shaping

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Liquid crystals offer a unique versatile platform for optical phase control and wavefront shaping. In particular, liquid crystal textures such as planar and twisted nematics, homeotropic and their umbilical defects, allow manipulation of optical wavefronts in different configurations. Optical vortex beams are dynamically created either via two-beam interaction in an optically addressed spatial light modulator or directly by the anisotropy stabilized self-induction of vortex-like defects. I will present a review on optical phase manipulation in this kind of systems as well as more recent results on the control of light by means of geometric Berry phase.

Likely chaotic transitions of large-scale fluid flows using a stochastic transport model

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Characterizing and tracking the chaotic transitions of a flow model is generally not an easy task. This problem is still a major issue in ensemble forecasting for climate predictions and for simulating geophysical flows. A natural way to explore likely transitions consists in randomizing the model parameters, the initial condition or the dynamics through a random forcing. Randomizing the initial conditions seems the more natural way to study chaos. However, the initial perturbations of interest mostly live at small spatial scales. Without prior, a lot of realizations are thus needed to well represent all those possible perturbations. Moreover, at the resolved scales, numerical simulations make use of diffusive operator to model the effect of unresolved velocity. Therefore, initial small-scale perturbations are often diffused before triggering any chaotic transition. Randomizing the dynamics can then more continuously introduces small-scales perturbations.
Here, general randomized fluid dynamic models rely on the decomposition of the velocity between a large-scale component and a random one, Gaussian, uncorrelated in time, possibly anisotropic and inhomogeneous in space. Using the Ito-Wentzell formula, the stochastic partial differential equation of a tracer transported is derived. This equation introduces a drift correction, an inhomogeneous anisotropic diffusion and a multiplicative noise. As interpreted, the two first terms provide a theoretical justification and a generalization of many empirical

deterministic subgrid tensors. This conservative model thus readily provides a clear physical link between the amount of numerical diffusion and the amount of noise.
To illustrate our purpose, simulations at high-resolution of a Surface Quasi-Geostrophic model have been performed. Metastable symmetries in the initial condition break after 40 days of advection, leading to a deterministic chaotic transition. For a fixed initial condition, the deterministic simulation at a coarser resolution appears to follow a completely different transition than the high-resolution simulation, leading to large errors. Contrarily, low-resolution stochastic model simulations are found to follow and well capture both transitions with only 200 realizations.
Keywords: Chaotic transition, stochastic subgrid tensor, geophysical fluid dynamics, ensemble forecasts.

Effect Of Swirl On Aerodynamic Behavior in a Mixture Combustor (Air-C12h23)

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The understanding of turbulent combustion represents a capital interest in the field of non-reactive flows. Non-premixed turbulent flames are a type of this combustion. They received a special interest in this work, as found in various domestic and technological applications.
This work is a contribution to the numerical study, a swirling flow with no chemical reaction in a simple room with a sudden enlargement at the entrance and exit.
Numerical simulation of a turbulent flow unreactive with and without swirl in a combustion chamber of the turbojet CFM56-7B.
The k-ε model is used to model the turbulence. The geometric model and the boundary conditions were developed using the mesh generator "GAMBIT" program. The different numerical simulations were made using the computational code finite volume FLUENT.
Interesting results were obtained regarding the dynamic fields, the mass fractions of the various species involved in the process.
Keywords: Swirl, turbulent combustion, non-premixed flame

Chaotic Attractors in Stochastic Hopf-Bifurcations

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Unlike Hopf-bifurcations in deterministic systems were a pair of complex conjugate eigenvalues traverse the imaginary axis simultaneously, stochastic Hopf-bifurcations exhibit a sequential crossing of the eigenvalues. Thereby, instead of a limit cycle, a chaotic attractor is established that governs the dynamics during and after the change of stability. Exploiting novel simulation methods based on a cohomolgy between flows generated by stochastic and random ordinary differential equations we numerically study the generation and development this chaotic attractor and determine some of its key characteristics including subsets of its basin of mean-square stability.

Tests to reduce toxicity of Lead by interaction selective: Lead/Zinc and Lead/Copper; In vitro Tests using Phaseolus-vulgaris plant

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One of the crucial problems in matters of pollution is the accumulation of heavy metals and specifically lead throughout the food chain, and transfers to the man. And as this element to the ability to cross all barriers and reaching the human body and cause a serious chronic poisoning such as lead poisoning on the nervous system. It is in this context that our study is to reduce the toxicity of the element by applying the selective interaction mechanism Lead / Zinc and Lead / Copper to seek to optimize the antagonistic effect with an Application In -Vitro on the phaseolus vulgaris plant.
Keywords: Lead, Pollution, Interaction, Zinc, Copper, Investigation, Antagonistic effect, Phaseolus-vulgaris.

Zero-Hopf Bifurcation in the Rossler Second System

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This paper is devoted to study the zero-Hopf bifurcation of the Rossler Second system. We characteristic the parameters for which a zero-Hopf equilibrium point takes place at each points. We prove that there are three 1-parameter families exhibiting such equilibria. The averaging theory of the first order is also applied to prove the existence of one periodic orbit bifurcating from the zero–Hopf equilibrium at the origin and

any information about the possible periodic orbits bifurcating from the zero-Hopf equilibria at the others is not provided by this theorem.
Keywords: Rossler second systems, periodic orbit, averaging theory, zero Hopf bifurcation.

Integrability checks for Nonlinear dynamical problems

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There is no unified characterization, nor universal definition of integrability. The study of integrability from different perspectives has lead to an ostensible fragmented notion of the concept. The aim of this talk is to give a comprehensive account of quasi-algorithmical approaches to “detect integrability” of equations. We briefly describe some ways of checking when an equation can be integrable, if we understand integrability as the exact solvability or regular behavior of solutions of the equation. In particular, we focus on ODEs and PDEs endowed with a Lax formalism. We derive some of their particular solutions, for example, a variety of exotic solitons, with further insight into their dynamical properties and their relevant physical and scientific meaning.
Keywords: integrability, painleve method, solitons, PDEs, fluid dynamics, lumps, peakons, darboux transformations, reciprocal transformations, lax pairs.

Symmetry breaking and odd resonances

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Starting from numerical simulations on the dynamics of a simple planar pendulum under harmonic parametric excitation, given by $S(t)=Acos(2 pi f_p t)$, comparison of parameter spaces (f_p, A), when the pivot is excited (i) along the vertical direction or (ii) along an arbitrary direction, tilted by an angle $phi = pi / 8$ with respect to the vertical line, both computed for fixed initial conditions $(theta(0), omega(0))=(pi/5.7, 0)$, revealed an outstanding difference: while in the tilted (asymmetric) case all primary resonances are observed, in the vertical (symmetric) case only even resonances can be found. Odd resonances are very rarely observed for the parametric pendulum, so their stability for large parameter ranges is noteworthy, and whether or not their occurrence is related to the symmetry breaking is a clamant question. The loci of bifurcations o! n parameter space was computed with the aid of numeric continuation technique. We determined that resonances n=1, 3, 4 and 5 (when they appear) arise from saddle-node bifurcations, while resonance n=2 comes about from pitchfork bifurcations in the vertical case, and from period-doubling bifurcations in the tilted case. Yet, another difference, is that for $phi=0$, there are regions in the parameter space of stabilized angular positions while for $phi neq 0$, they no longer exist and new regions appear in which stable periodic oscillations take place. To validate these numerical observations, we constructed experimental bifurcation diagrams for the tilted parametric pendulum, fixing the amplitude A and varying the frequency f_p of the excitation. The experimental data are the time series of the absolute value of the angular speed $omega$, which are analyzed through Poincaré (stroboscopic) sections S=0. These maps give origin to first return maps $|omega_{n+1}| times |om! ega_{n}|$, so the map periodicity is given by n$=f_p/f_{osc}$.! We showed that odd resonances indeed occur in the asymmetric case, and also that n=3, 4 and 5 oscillatory attractors coexist with n=1 oscillations. This main difference between the symmetric and non-symmetric cases, i. e., the occurrence of odd resonances,was explained by the Melnikov method for subharmonic solutions. We not only demonstrated that the loci of saddle-node bifurcations that is the threshold obtained by application of this method excellently agrees with those computed using numeric continuation technique, what implies that primary resonances are indeed described by this method, but also showed that whereas even resonances are due to the vertical excitation component, odd resonances are a result of an extra torque that appears only in the tilted case, as a consequence of the symmetry breaking of the equations of motion.

Keywords: Parametric systems, Melnikov method, Chaotic simulation.

Inter-layer synchronization in multiplex networks of chaotic oscillators

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In the last few years, and taking advantadge of the increased resolution in databases, real complex systems, like online social networks, are benefiting from a representation of several layers of networks interrelated between them. When the layers are composed of the same

nodes and the only interrelations are those between the same nodes in the different layers, the multilayer structure is called a multiplex. Such a representation helps understanding, for instance, the spreading of an epidemic process due to social interactions occurring at different levels, like the physical and online levels. As far as the emergence of collective dynamical pheomena is concerned, we focus here on a yet unnoticed phenomenon in a multiplex network: inter-layer synchronization of chaotic oscillators, where each constituent in a given layer of a system undergoes a synchronous evolution with all its replicas in other layers, regar! dless of whether or not it is synchronized with the other units of the same layer. In particular, we derive the conditions for the existence and stability of such a solution and inspect its robustness by means of numerical simulations and experiments with multiplexes of nonlinear electronic circuits. Our finding actually gives novel hints towards understanding how, for instance, biological systems can collectively organize in a redundant way, so that their effective functioning occurs through distinct (yet synchronized) layers of interactions.
Keywords: chaotic synchronization, multilayer networks

Role of noise threshold in the time statistics of avalanches recorded during plastic deformation

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Many natural dynamical systems display avalanche-like dynamics which is characterized by scale invariance reflected in power-law statistical distributions. The superposition of avalanche processes in real systems driven at a finite velocity may influence the experimental determination of the underlying power law. Recent study of the possible effect of noise threshold on the avalanche amplitude statistics showed that the power-law exponents are quite robust in a wide threshold range even in the conditions leading to a very strong superposition of avalanches [1]. The occurrence of a power-law scaling is often ascribed to the phenomenon of self-organized criticality in dynamical systems [2]. This conjecture implies that both the size and duration of avalanches obey power-law distributions. However, the duration statistics is usually omitted from the analysis of experimental data because the durations depend on various artifacts, such as avalanche overlapping, noise, and so on. The present work aims to examine the sensitivity of the apparent duration statistics to the noise threshold applied to individualize avalanches within experimental signals. The statistical analysis was performed on acoustic emission (AE) signals accompanying plastic deformation of an AlMg alloy. Power-law distributions of AE event durations were found in wide ranges of the noise threshold parameter. Importantly, the data obtained provide an experimental proof that the signal thresholding may lead to a transition from Poisson to power-law distributions of waiting times, as predicted recently [3].

Keywords: Self-organized criticality, Avalanches, Plastic deformation, Noise

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Study of period doubling and homoclinic bifurcations in glow discharge plasma in the presence of a bar magnet

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The present work is the study of nonlinear dynamical behaviour of glow discharge plasma where a transition from order to chaos via period doubling bifurcation is observed with the increase in the magnetic field strength. This transition is analyzed by using bifurcation diagram, phase space, power spectrum plots, Hilbert Haung transform and by estimating the largest Lyapunov exponent. In addition to this, an evidence of normal homoclinic as well as inverse homoclinic bifurcation is shown.

Keywords: Glow dischage plasma, Bifurcation, Hilbert-Huang transform

On the Extension of the Nonlinear Feedback Loop in a Seven-dimensional Lorenz Model

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In this study, we construct a seven-dimensional Lorenz Model (7DLM) to extend the nonlinear feedback loop of the 5DLM and examine its impact on solutions' stability. Two new modes are selected based on the analysis of the nonlinear temperature advection term, a Jacobian term ($J(psi, theta)$). Here, psi and $theta$ represents the streamfunction and temperature perturbations, respectively. It is shown that the further

extension of the nonlinear feedback loop within the 7DLM can provide negative nonlinear feedback to stabilize solutions and thus leads to a much larger critical value for the Rayleigh parameter (rc sim 116.9) for the onset of chaos, as compared to the rc of 24.74 for the 3DLM and the rc of 42.9 for the 5DLM. To assure that the 7DLM is more stable than the 3DLM and 5DLM, we have performed the calculation of Lyapunov exponents using selected values of the Prandtl number and performed linear stability analysis near the critical points using different values of Rayleigh parameter ($40 le r le 220$) and the Prandtl number ($ 5 le sigma le 25$) by obtaining and using the analytical solutions of the critical points for the 7DLM.

Keywords: Lorenz model, Chaos and Predictability

The investigation of dynamics of non-ideal pendulum systems without any limitations of their parameters

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In the book [1] it was built a number of mathematical models of various non-ideal pendulum systems. However the study of these models were conducted by using the method of averaging, which requires the introduction of a small parameter. This leads to a simplification of the original models of considered systems and to the significant limitations that are imposed on their parameters.
In this work a study of the dynamics of some non-ideal pendulum models, without application of methods of a small parameter, are carried out. A system of equations in normal form was deduced. The investigation of stability of steady-state regimes was conducted. Demonstrated the possibility of occurrence the deterministic chaos in such most accurate models of non-ideal pendulum systems.

Keywords: non-ideal pendulum system, stability conditions, deterministic chaos.

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The influence of delay factors on the genesis of deterministic chaos in non-ideal pendulum systems

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The dynamics of non-ideal dynamical system “pendulum – electric motor” with taking into account various factors of delay is considered. Mathematical model of the system is a system of ordinary differential equations with delay. The approaches that reduce the mathematical model of this system to the system of three, nine or fifteen differential equations without delay are suggested. The influence of delay factors on steady-state regimes of the “pendulum – electric motor” system is studied. Maps of dynamical regimes, the dependencies of maximal non-zero Lyapunov's characteristic exponent from the delay, phase-parametric characteristics are built and analyzed. The scenarios of transition from steady-state regular regimes to chaotic regimes are identified.
It is shown that neglecting the presence of delay in such systems may affect the qualitative change in their dynamics. In some cases the delay is the main reason of origination as well as vanishing of chaotic attractors. In particular, detected atypical symmetrical situations in alternation of different scenarios of transition to deterministic chaos. The use of three-dimensional mathematical model to study the dynamics of “pendulum – electric motor” systems is sufficient only at small values of the delay. For relatively high values of the delay, multi-dimensional system of nine or fifteen equations should be used.
Keywords: pendulum system, regular and chaotic attractors, maps of dynamical regimes, scenarios of transition to chaos.

Advances in Enhancing Fluid Transfer Capabilities Using Fractal Architecture

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The industries and the processes dealing with heat transfer and fluid transport show a great interest in enhancing the transport phenomena for better productivity and improved performance. Fractal structures provide the architecture for improved fluid transfer due to their ability of maximizing the surface area for the exchanging fluids in compact volumes. Fractals are self-replicating structures at multiple length scales. The fractals are characterized by fractional dimensions unlike the Euclidean geometry. The economic gains associated with the fractal model in terms of accurate prediction of productivity have sparked a serious interest in the field of fractal research. Fractal structures provide the appropriate technology for the enhancement in the fluid transfer capabilities.
The application of the proposed fractal model will show an enhancement in the flow rate for a given pressure drop. The objective of this study is to determine the sensitivity of the fluid flow, pressure drop, permeability,

porosity of a porous medium to the fluctuations in the fractal dimension. A fractal tree is precisely investigated in this paper. The observed fundamental parameters characterizing the fractal tree help in establishing the most effective path for the optimum and improved fluid flow through the fractal tree branches. The chosen fractal architectures in this study have been seen to enhance the permeability of the fractal reservoirs due to the augmentation of surface area in the fractal branching networks of varying length-scales. The model would shed light on the benefits of increasing the oil recovery by investigating the sensitivity of the production flow rate on the various rock properties and fluid properties. This generalized model will determine the v! arious attributes of the fluid flow through the fractal architecture, regardless of its complex and random path.

KEYWORDS
Fractal, Permeability, Porous Media, Enhanced Flow Rate.

Fermi acceleration in a FU-model with a structured particle

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Fermi acceleration (FA) is a process in which a particle gains unlimited amounts of energy due to successive collisions with a moving wall. FA has been studied since 1949 when Fermi proposed a model (Fermi-Ulam or FU model) to try to explain the high energy of some cosmic ray particles. The model consists of a classical particle moving freely between two walls, one fixed and one moving. In this model FA can be achieved for some protocols of wall movement. In this work we study the FU model replacing the point particle a structured particle consisting of two simple particles connected by a harmonic and/or a quartic spring.
When both walls are fixed the total energy of the particles determines the general behavior of the system which is chaotic at low energies but exhibits a rich phase space structure at high energies.
We used a protocol in which the wall moves periodically approaching the particles at a constant speed and abruptly returning to its initial position. This protocol leads to FA when a single particle is used in the FU model. For the structured particle FA is still observed but the rate of energy gain is significantly smaller. We found that this is due to two mechanisms:
(i) There is a decrease in the rate of collisions between the structured particle and the wall. Part of the energy gained is absorbed by the internal degrees of freedom, resulting in a slower center of mass. As a consequence the time interval between successive collisions increases. This effect is more pronounced for stronger springs but the type of spring (harmonic or quartic) is not important.

(ii) The spring slightly reduces the amount of energy gained by the center of mass at each collision. After an initial transient the energy gain as a function of the number of collision stabilizes in a regime of a constant growth. We found the same rate of energy growth for all the types and strengths of springs we used. We also found that the rate of energy growth (as a function of the number of collisions) for the total system is the same as for the center of mass alone. In both cases the rate found for the FU model with a structured particle was slightly smaller than what is found for a single particle in the same conditions.
Overall our results show that the internal degrees of freedom in a structured particle are an important factor for the rate of energy gain in the FU model.
Keywords: Fermi acceleration, Fermi-Ulam model. Center of mass, Dynamic systems

A first and second order approximation model for the first exit time densities problem

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The following first approximation for the first exit time densities of a Brownian motion through one-sided moving boundaries to model the life table data sets in Demography was proposed by Skiadas and Skiadas [1]:

$$f_x = \left(\frac{2}{\sqrt{2\pi}}\right)\left(\frac{|H_x - xH'_x|}{\sqrt{x^3}}\right)e^{-\frac{H_x^2}{2x}} \quad (1)$$

$H(x)$ is a function of health at age x and $f(x)$ is the death probability density function.
Here we introduce the term $(2/\sqrt{2\pi})$analogous to the related term of the half-normal distribution. This form has a relatively good fitting as is presented in figure 1 A, B. It is clear that the estimates in the age period from 15 to 50 years the model underestimates the related figures.
However, a second order approximation in the following form can improve fitting:

$$f_x = \left(\frac{2}{\sqrt{2\pi}}\right)\left(\frac{|H_x - xH'_x|}{\sqrt{x^3}} - \frac{k\sqrt{x^3}H''_x}{2|H_x - xH'_x|}\right)e^{-\frac{H_x^2}{2x}} \quad (2)$$

The parameter k expresses the level of the influence of the second order correction term. When k=0 the last equation form reduces to the first order approximation. The next step is to insert in (2) the 3-parameter (b, l, c) expression $H(x) = l - (bx)^c$ introduced by Skiadas and Skiadas [2] for $H(x)$ to find the following form of model (3):

$$f_x = \left(\frac{2}{\sqrt{2\pi}}\right)\left(\frac{|l+(c-1)(bx)^c|}{\sqrt{x^3}} + \frac{k\sqrt{x^3}c(c-1)b^c x^{(c-2)}}{2|l+(c-1)(bx)^c|}\right)e^{-\frac{\left(l-(bx)^c\right)^2}{2x}} \tag{3}$$

This is a 4-parameter model providing quite well fitting for the death probability density data and for the logarithm of the force of mortality μ_x. We call (3) as Infant Mortality Model, IM-Model, giving quite good estimates for the infant mortality but also very good estimates for all the period of the life time as is illustrated in Figures 1C and 1D for USA males in 2010.

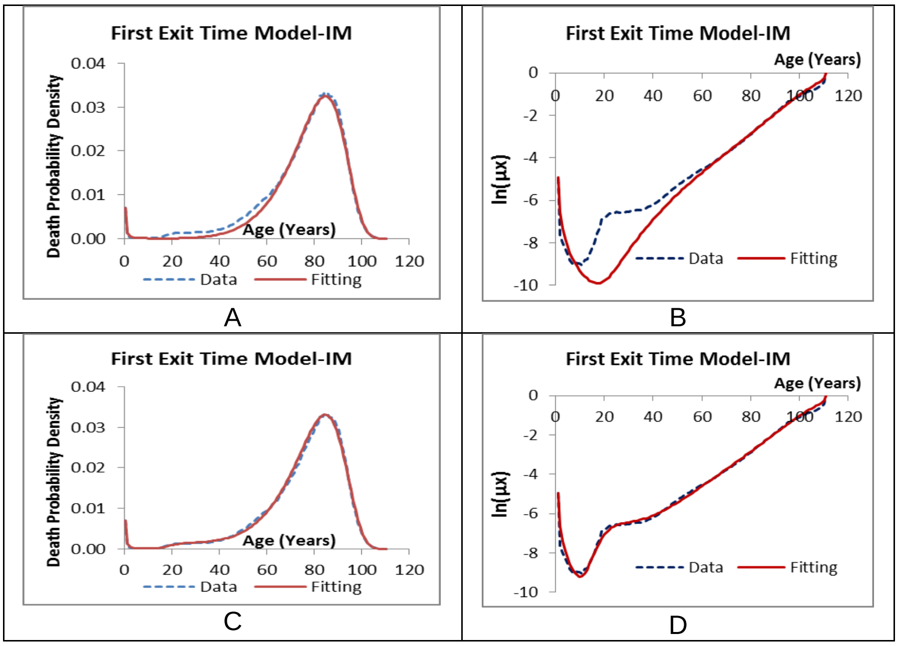

Fig. 1. Death Probability Density $g(x)$ and Logarithm of the Force of Mortality $\mu(x)$ for the IM-Model. First order approximation (A and B) and second order approximation (C and D). Data for USA males, 2010.

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Universality and Statistical Nature of Turbulence, Quantum Mechanics, and Chaos

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A scale invariant model of statistical mechanics is applied to reveal the universality of the problems of turbulence, quantum mechanics, and chaos theory. Closure of the gap between the problems of turbulence and quantum mechanics is described through connections between Cauchy, Euler, and Bernoulli equations of hydrodynamics, Hamilton–Jacobi equation of classical mechanics, and finally Schrödinger equation of quantum mechanics. Feigenbaum universal period-doubling and scale-factor constants (δ, α) are respectively related to De Pretto number 8338 J/kcal or universal gas constant R^{o} = 8.3384 kJ/(kmol-m) and atomic mass unit.
Keywords: Turbulence, quantum mechanics, chaos, Feigenbaum constants, TOE.

Shilnikov testing of Erbium doped fiber laser chaos

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The Silnikov theorem is an analytical criterion to prove the existence of chaos in three dimensional nonlinear systems. It requires that at least one of the fixed points should be of saddle focus type for chaos to occur. This paper presents Erbium Doped Fiber Ring Laser (EDFRL) as a practical system which lacks the existence of a saddle focus type fixed point, hence violating Silnikov theorem, still generates chaos for some parameter range. A study of linear stability, nature and dynamics of fixed points is also presented using theoretical and numerical approach.

Chaos and Order in Weather and Climate Dynamics

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It is widely accepted to believe that the atmospheric dynamics is chaotic, and so unpredictable for more or less distant future. It is because all solutions of the equations governing the dynamics are unstable to small disturbances of their initial data. The aim of this report is to demonstrate that it is not fatal as seen because an order always co-exists with the chaos induced by these instabilities. Taking this order into account it is possible to exclude these instabilities from further consideration. It is important that the degree of the mutual atmospheric ordering increases when larger and larger timescale components of the atmospheric processes are considered. In particular, the processes of the interannual variations (like El-Nino – Southern Oscillation) are affected by several external forces with incommensurate periods. The same is true for the processes within the timescales of decades and hundred thousands of years (the glacial cycles of climate). By this reason, the attractors of these processes can be treated well as strange but nonchaotic. This fact opens the door for super- and hyper- long term climatic predictions.
Keywords: Weather chaos, Strange nonchaotic climatic variations.

Semiautonomous Multiparametric Control in Electroacoustic Music: A primary approach to numerical procedural art

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Electroacoustic music is mostly concerned with the generation of continuously changing sonic events defined by several properties like space, timbre, rhythm, dynamics, pitch-noise degree, etc. This paper offers an alternative approach of spectromorphological explorations based on the semiautonomous multiparametric control of one or several digital transformations over sound sources using dynamical systems such as chaotic mappings and automata. By being able to simultaneously manipulate multiple parameters of digital transformation over sounding bodies or sound events, the user can explore and generate a wide field of spectromorphological possibilities. This kind of behavior is attained by computational numerical-procedural perspective which places itself as a broader and more general theoretical classification rather than the so called algorithmic art.
Keywords: Chaotic modeling, Algorithmic music, Computer-based music, algorithmic real time control.

Synchronization of Small-World Networks with Multi-Scroll Chaotic Oscillators

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In this paper, authors study the synchronization of a small-world network. We consider chaotic generators of multi-scroll attractor to compose the complex network. By applying Newman-Watts algorithm, we introduce long-range connections in an arrangement of N-coupled chaotic oscillators, attempting to improve communication between the oscillators. Authors will show that the small-world property allows us to synchronize a complex network by using a small coupling strength. Chaotic synchronization is achieved by using the complex systems theory. Numerical simulations are provided to show the effectiveness of the method.

Keywords: Chaos synchronization, small-world networks, multi-scroll chaotic attractors.

The Mechanisms of Freedom, Uncertainty and Randomness in Strictly Formal Disharmonized Phenomena

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The paper investigates the deduction of derivative metaconcepts of Freedom, Uncertainty and Randomness from the earlier obtained metaconcept of Chaos by means of special conceptual Universe's Model that considers the highest properties of the Universe. It is shown that deformalizing properties of Freedom, Uncertainty and Randomness naturally arise in any even strictly formal phenomena and are absolutely necessary for their development and further harmonization. The universal definitions of these metaconcepts are offered, and the mechanisms of their origin are classified. The natural instability of chaotic phenomena which is applied to manage them is shown. The use of potentials of connectivity in space of phenomena conditions for the synthesis of phenomena with the required properties of stability and controllability is substantiated. The obtained definition can serve as a conceptual and methodological tool in specific research and development.

Keywords: Universe’s Model, Metaconcept, Harmony, Chaos, Freedom, Uncertainty, Randomness.

The Ground Motion Spectrum of a Logistic Map Fault Slip Resembles that of a Constant Slip

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Ground motion caused by a rupturing earthquake fault may be expressed as a space-time convolution of the slip function with impulse response over the fault plane. Taking the Fourier transform, decouples the two effects and allows a separate examination of the effect of slip and fault finiteness on the frequency spectrum of the far-field motion. The purpose of the present paper is to address the issue of why the physically unrealizable constant slip, which requires infinite concentration of energy at the ends of the fault plane, yields synthesized seismograms that often match seismograms recorded from actual earthquakes better than seismograms synthesized from physically realizable slips. An explanation is achieved by comparing the far-field frequency spectra generated by different kinematic slip models in so far as spatial dependence is concerned. Specifically, slips that are dependent on each other from point to point on the fault plane are examined in addition to slips considered earlier in the literature that only depend on fault point location and are independent of each other. The former case will be represented by a logistic map while the latter case will be represented by slips that vary over the fault length in an elliptic, constant or parabolic fashion. It is found that for unidirectional rupture along the fault length, the logistic map slip gives a frequency spectrum whose envelope decays as y^-1, the same as that of a constant slip envelope, where y is a non-dimensional frequency defined as y=πfL/v, f being the frequency, L the fault-length, and v the velocity with which slip propagates along the fault modified by the phase velocity of the emitted wave. On the other hand, the spectrum envelopes of the elliptic and parabolic slips decay as y^-3/2 and y^-2, respectively. It is interesting that the frequency spectrum envelope of the logistic map slip, a physically realizable slip, resembles that of the physically unrealizable const! ant slip and not the envelopes of slips which are physically realizable but independent of each other from point to point on the fault plane. The results obtained can benefit the synthesis of ground motions from kinematic slip models, to be used as input for the design of earthquake resistant structures.
Keywords: earthquake ground motion, kinematic model, slip function, logistic map, frequency spectrum.

Analysis of two simple pendulae interacting harmonically

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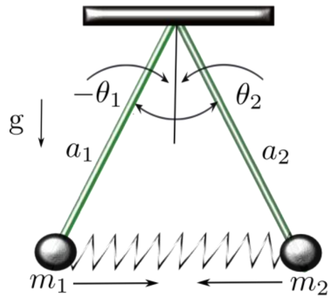
We consider the system of two simple pendulae that interact by elastic forces according to the Hoke's law. The analysis of global dynamics by means of Poincare sections shows the large chaotic regions, which suggest that the system is not integrable. We give the analytical proof of this fact by means of the Morales-Ramis theory that connect the integrability with properties of differential Galois group of variational equations obtained by the linearization of the system along a particular non-equilibrium solution. Moreover, using the Birkhoff normalization we make the stability analysis of the system in the neighborhood of its equilibrium. In particular, we look for values of parameters for which equilibrium is linearly stable; we make the analytical Poincare cross sections, as well as we plot the resonance curves and we look for periodic solution corresponding to them.



Keywords: Chaos, Poincare cross sections, Non-integrability, Morales-Ramis theory, Defferential Galois theory, Birkhoff normalization.

Conception of a Cryptosystem by Blocks Using Chaotic Maps

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Securing the transmission of information, the effective protection of data streams constantly growing, protection against unauthorized listening and sharing are essential especially for military, medical, and industrial applications.
The aim of this work is to explain how to use chaotic maps for the design of a crypto-system block, and insist on the two basic concepts of degree of resistance against cryptographic attacks, namely the confusion and diffusion.

Keywords: Cryptosystem, chaotic map, Shannon structure; chaotic generator

Study on Novel Chaos Generalized Synchronization Discrete Systems with Application

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Many fields need pseudorandom numbers, in particular in cryptographic applications. Chaos generalized synchronization (CGS) systems provide possibilities for designing pseudorandom number generators (PRNGs) with promising randomness and large key spaces. Firstly this study introduces three novel 4-dimesional discrete chaotic systems, and constructs three 8-dimesional CGS systems. Numerical simulations show that the dynamical behaviors of the three 8-dimesional CGS systems are in good agreements with theoretical expect s. Secondly using the CGS systems designs three 212 word PRNGs. Thirdly, this study uses a FIPS 140 based 2d word pseudorandom sequence test suite [1] tests the pseudorandom performance of the three CPRNGs, and compares with the RC4 algorithm. The results show that the randomness performances of three CPRNGs are promising. The research results of this study suggest that CGS systems are good candidates for designing 2d word PRNGs, which can be used in avalanche encryption scheme [2].

Keywords: Discrete chaos system; Generalized synchronization; Pseudorandom number generator, Pseudorandomness test.

Acknowledgments The authors would like to thank Longjie Hao at the Peking University Founder Group Electronic Co., Ltd. for computer program assistance. This study is supported by the Student Innovation Fund of the University of Science and Technology Beijing, and the Fund of Improving Conditions of Running National Ordinary Universities of China.

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A Nonlinear Dynamic Perspective on the Activity on Social Networks

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The new phenomenon represented by the Social Networks (SNs) is little investigated yet, although it reveals several interesting social and informational issues related to the response of the public to events. Such issues pertain to the social sciences as it is a social effect; it also pertains to nonlinear dynamics, as the SNs are nonlinear systems and the response to events is a typical dynamic process. In a series of previous papers, empirical and semi-empirical models were developed for the response of the SNs to events, based on a set of monitored SNs traffic reacting to several disasters. Moreover, 'SNs noise' was analyzed for the same cases. In this paper, we apply tools from the field of non-linear dynamics to further investigate the SNs' responses to disasters and other critical events. A special emphasis is on the network processes and their specific dynamics, in correlation with the dynamics of the events that produce the respective traffic in the SNs.
Questions answered refer to effects such as 'fatigue' and 'forgetting' processes occurring in the SNs traffic, delays in the response, latency of the response, and specific responses depending on other factors than the gravity of the disaster, where the disaster gravity is determined by the number of victims and injured persons.
Keywords: nonlinear dynamics, social networks, response to events, network effects, response parameters, cause-effect correlation.

Practical applications of spatio-temporal instabilities in optical fibre systems

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Abstract to be defined???????????

On The Synchronization Phenomenon of Spin Torque Nano-Oscillators

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The emergence of spin-transfer physics over the last decade has improved our fundamental understanding of the interactions of the

electrons and magnetism and enabled new approaches for current-controlled magnetism at the nano-scale. The direct injection of spin-polarized electrons into a nano-magnet transfers the angular moments from the electron, which facilitates a local torque on the magnetization. This spin torque can oppose the intrinsic damping of the magnetic layer exciting steady state oscillations, forming a Spin Torque Nano-Oscillator (STNO). Then the Giant Magnetoresistance Effect can convert the magnetic precession of the STNO into microwave voltage signals and turn the valve into a microwave signal generator at the nano-scale. The microwave power output measured in experiments is, however, rather small, about 250 pW. To generate a more powerful signal, several groups have proposed to harness the power of several STNOs oscillating in synchrony while connected together. Achieving synchronization has proven to be, however, rather difficult for even small arrays while in larger ones the task of synchronization has eluded theorist and experimentalists altogether. In this work we produce analytical expressions for the loci of the Hopf, symmetry-preserving, bifurcations that lead a series array of STNOs of arbitrary size N into synchronization. We exploit the symmetry of the array to find implicit analytic expression for the Hopf boundary curves of the synchronization state and other patterns of oscillations as well. Through a stability analysis we are able to map out the region of parameter space where the synchronization state and its manifold are both stable. Results illustrate the ideal regions of operation of large arrays, up to N=1000 nano valves, which should yield considerable higher microwave output.
Keywords: Spintronics, Networks, Nano-scale Oscillators, Symmetry, Bifurcation, Synchronization, Microwave Signals, Giant Magnetoresistance Effect.

Some risk assessments at nuclear power plants (NPP).

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Today NPP energy production is constantly and intensive increases in the world with the growth of different threats under its exploitation, that cause by natural and manmade factors, including possible directed terrorist attacks. It is necessary correct assessments of corresponding risks levels during NPP projecting, building and exploitation under its complex integrated emergency management [1]. Here we analyze some possible methods of risk assessments and the using of our universal formula for calculation of total vector of limited losses under NPP exploitation for the fixed time interval under the following assumptions [2]: (1) at initial state the object is in normal (non accidents) exploitation; (2) the different kinds of accidents may be occurred as noticed i =2, 3, …, m, where m is the total number of possible accidents (m=1 is corresponded to the normal regime); (3) every accident may create the different kinds of losses. (4) realization of i accident creates the loss of j kind with Pij probability:

$$\vec{a}_{\lim} = P(1)\vec{a}_{1n} + \sum_{i=2}^{m} \hat{P}_{ij}\vec{a}_j \qquad (1)$$

Here j is the kind of loss with aj. value. Then j = 1,2, …n, where n is the total number of possible kinds of losses; where P(1) is the probability of loss formation under normal exploitation; $\vec{a}_{1n}$ is the vector of limited loss under regular exploitation. $P_{ij}a_j$ value in sum is equal the loss value of j kind under realization of i kind accident. Under absent of accidents (normal regime) $\vec{a}_{\lim}$ is determined only the first part of (1) formula.

The main problem is P_{ij} assessment. Usually the representative statistic data for its assessment are present for only long NPP normal exploitation period. Early we predicted the irradiation doses and corresponded risks for population under implementation of Russian Federal Program:" Development of Russian atomic energy industrial complex on 2007-2020 years at 10 homeland NPP, that operated during some last decades [3]. Such data are absent for NPP non prognostic emergencies, when part of needed information may be obtained only after its disasters. Some NPP are located in dangerous regions and exposed to negative natural responses (earthquakes, tsunami, for example at Armenian, Kazakhstan and Japan NPP) or manmade ones in dangerous conflicts zones with high terrorism threats. Here the using of classic methods of expertise risk NPP assessments are not correct and often impossible at all. Some needed data may be obtained from primary virtual computer tests of individual NPP with imitation of possible disasters. It allows to plan the actions for NPP operators and special services under serious NPP disasters or may be to prevent them at all. These problems are under consideration in our communication.

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CHAOTIC SOLUTIONS AND GLOBAL INDETERMINACY IN A RESOURCE OPTIMAL MODEL

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The paper investigates the dynamical properties of a resource optimal system derived by Wirl (2004) and Bella (2010). To this end, we determine the whole set of conditions which lead to global indeterminacy and, eventually, chaotic behavior outside the small neighborhood of the Balance Growth Path (see, for example, Mattana et al., 2009, Nishimura and Shigoka, 2006, Venturi, 2014).The model possesses a rich spectrum of dynamic behavior that goes, as the parameters of the model are tuned, from a stable equilibrium point to a Hopf cycles, either super-critical or sub-critical (see Mattana and Venturi 1999, Neri and Venturi 2007). Here, we focus on a parameter region of local determinacy. We show the possibility of global indeterminacy and chaos in its subset. Our route to chaos exploits the existence of a homoclinic orbit to a saddle-focus equilibrium. The dynamics near these homoclinic orbits has been discovered and investigated by using the Shilnikov Theorem. This involves hyperbolic horseshoes close to the homoclinic orbit, but possibly also periodic attractors and strange attractors. It might be impossible to characterize the system for a full set of parameter spaces, and the boundary of a chaotic region. We describe the "routes to chaos", and a bifurcation diagram, where one could see how a change in some parameters can lead to a series of bifurcations: the emergence of a saddle-focus, of a homoclinic orbit, and chaos.
Keywords: Externality, Global Indeterminacy, Homoclinic orbits, Chaos Attractor.

The Estimation of Transmission Information Quality in Secure Communication Systems Based on Deterministic Chaos

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The development of communication systems based on chaotic signal generators for hidden data transmission is topical issue in modern scientific researches. However a level of information hiding depends on values of parameters system and choice of transmission scheme. The target of this paper is the estimation of secrecy degree and quality of information transmission for different analog and digital communication schemes (chaotic masking, modified chaotic masking, chaotic switching, chaotic modulation and chaotic non-autonomous modulation) based on complete chaos synchronization.
To quantify the degree of information hiding in the channel there was carried out the comparative analysis of statistical and spectral characteristics of chaotic signals and additive sum of both chaotic and information signals. There were obtained the requirements the signals should have to provide the necessary degree of hidden data transmission. Numerical calculations of bit error ratio (BER) for different schemes of digital communication were performed, and the sensitive of each of them to channel noise was shown.
Keywords: Secure communication, Chaotic signal generators, Statistical and spectral characteristics, Bit error ratio.

Fast True Random Number Generation with Optical Heterodyne Chaos at 5 ×80 Gb/s

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Fast true random number generation is of paramount importance for modern applications such as Monte Carlo simulations, real time data encryption, stochastic modeling, etc. A combination of chaotic external-cavity laser diodes and least significant bits (LSBs) extraction accompanied by complicated operations such as delayed-difference, high-order derivatives, exclusive-OR, etc., has been widely investigated and employed in the fast generation of true random number. However, it is an ongoing challenge to develop more practically feasible methods for fast true random number generation. In this paper, we propose a simple scheme for fast true random number generation with optical heterodyne

chaos which employs the simplest LSBs extraction. The heterodyne chaos is experimentally generated by optical heterodyning of two external-cavity laser diodes. The heterodyne signal shows a flat and wide spectrum (3dB b! andwidth of 16GHz) without signatures of relaxation oscillation and external resonance which are both intrinsic to the dynamics of external-cavity laser diodes. In random number generation, the heterodyne-generated chaotic temporal waveforms are sampled at 80 GigaSample per second and converted into eight-bit values. By directly selecting 5 least significant bits from the eight-bit samples without more post-processing operations, an equivalent generation rate of 5 × 80 Gb/s is achieved with randomness examined by the National Institute of Standards and Technology test suite.

Keywords: Chaos, Heterodyning, Random number generation, Laser diodes.

Hopf Bifurcation Analysis in Generalized Lorenz Model

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We consider the stability of a generalized Lorenz system proposed by Macek and Strumik [1]. This four-dimensional model has an additional variable describing the role of the magnetic field induced in a convected magnetized fluid. In the present study we analyse this system depending on selected control parameters, by using Hurwitz-Routh methods [2]. In particular, we identify values of the control parameters for which Hopf bifurcation takes place and compare obtained results with the usual three-dimensional Lorenz system [2]. Finally, we prepare bifurcation diagrams basing on which we analyse the dynamics of the generalized Lorenz system, in particular near the Hopf bifurcation.

Keywords: Nonlinear systems, chaos, stability, Hopf bifurcation.

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Generating hidden hyperchaos in a 5D hyperchaotic Burke-Shaw system with three positive Lyapunov exponents

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This paper reports the finding of hidden hyperchaos in a 5D hyperchaotic Burke-Shaw system, which is obtained by adding feedback controllers to the classic Burke-Shaw system. Of particular interest is that the hidden hyperchaotic attractors can be generated with three positive Lyapunov exponents in the proposed system with no equilibria or only two stable equilibria. The region of parameter space with bounded hidden solutions is relatively small, which accounts for the difficulty of surveying hidden attractors. Numerical analysis of phase trajectories, Lyapunov exponents, and Poincar′e map verify the existence of the hidden hyperchaotic attractors. As we know, the feature has not been previously reported in any other high dimensional system. Therefore it will represent a new type of hidden attractor with important and potentially problematic engineering consequences.
Keywords: Hidden attractor; Hyperchaos; No-equilibrium; Stable equilibria; Lyapunov exponents.

Dynamical interactions of counterpropagating Airy beams

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We analyse theoretically the spatiotemporal dynamics of two incoherent counterpropagating Airy beams interacting in a photorefractive crystal under focusing conditions. For a large enough nonlinearity strength the interaction between the two Airy beams leads to light-induced waveguiding. The stability of the waveguide is determined by the crystal length, the nonlinearity strength and the beam's intensities and is improved when comparing to the situation using Gaussian beams. We further identify the threshold above which the waveguide is no longer static but evolves dynamically either time-periodically or even chaotically. Above the stability threshold, each Airy-soliton moves erratically between privileged output positions that correspond to the spatial positions of the lobes of the counterpropagating Airy beam. These results suggest new ways of creating dynamically varying waveguides, optical logic gates and chaos-based computing.

Steady-state bifurcation for a biological depletion model

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A two-species biological depletion model in a bounded domain is investigated in which one species is substrate and the other is activator. Firstly, under the no-flux boundary condition, the asymptotic stability of constant solutions are discussed. Secondly, by viewing the feed rate of the substrate as a parameter, the steady-state bifurcations from constant solutions are analyzed both in one-dimensional kernel case and in two-dimensional kernel case. Finally, numerical simulations are presented to illustrate our theoretical results. The main tools adopted here include the stability theory, the bifurcation theory, the techniques of space decomposition and the implicit function theory.
Keywords: Depletion model, asymptotic stability, steady-state bifurcation, numerical simulation.

Statistical Properties of Soft Mode Turbulence at The High Control Parameter in Nematic Liquid Crystal

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The Soft-mode turbulence (SMT) is one of the type of spatiotemporal chaos that has been found in electroconvection of homeotropically aligned nematic liquid crystal. This is caused by the result of nonlinear interaction between Nambu Goldstone mode and convective mode. The SMT at low control parameter $\varepsilon < 0.3$ has been analyzed using its autocorrelation. The autocorrelation fits using non-simple exponential, i.e., compressed exponential. Here, we conduct observation SMT at the wide range of control parameter. This result confirmed that there is crossover between dynamical heterogeneity to aging behavior in SMT at the low to high control parameter.
Keywords: Soft-mode turbulence, High control parameter, Autocorrelation, Stretched exponential, Dynamical heterogeneity, Aging behavior.

Chaotic and ballistic dynamics in time-driven randomized and quasiperiodic lattices

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In a spatiotemporally periodic Hamiltonian lattice, the Phase space is composed of chaotic, as well as of regular domains, corresponding to

either diffusive or ballistic particle motion. In our works, we investigate how the breaking of the spatial periodicity alters the dynamical evolution of particle ensembles. Specifically, we consider the cases of randomized perturbations, i.e. disorder, to an otherwise periodic lattice, as well as a quasiperiodic lattice based on the Fibonacci sequence. For the disordered case, we find the intriguing effect that, if the disorder is localized within some finite domain, initially diffusive particles are accumulated into the regular structures of the phase space [1]. For the quasiperiodic lattice, we demonstrate the emergence of extraordinarily long ballistic flights at distinct velocities, which can be explained by a hierarchy of block decompositions of the Fibonacci lattice [2].

Keywords: Chaos, Hamiltonian dynamics, Driven systems, Quasiperiodicity, Fibonacci lattice, ballistic flights.

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Lagrangian coherent structures in wave generated flows

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Complex flows can be generated by both the Faraday waves on a vertical vibrating shaker [1] and by propagating waves using a solid plunger [2]. Under various flow conditions, we observed the vertical vorticity generation, which results in the generation of two-dimensional turbulence on the water surface [3] and water wave tractor beam [2].

The understanding of statistical properties of Lagrangian trajectories [4] in complex flows is crucial for problems such as spreading of plankton in the ocean, transport of pollutants in the atmosphere, or rain initiation in clouds. Our recent results show that fluid particle dispersion is diffusive and is determined by a single measurable Lagrangian scale related to the forcing scale [4]. Turbulence however is a state of a flow dominated by a hierarchy of scales, and it is not clear which of these scales mostly affect particle dispersion. Moreover, coherent structures often coexist with turbulence, such as the small scale forcing in laboratory experiments, or the self-generated spectral condensation [5]. How those coherent structures affect particle dispersion is not well understood. Recently developments in scientific imaging and computational power make it possible to tackle this problem experimentally.

In our experiments, flows are generated in a wide range of kinetic energy, forcing scales and boundary conditions. We analysed the Lagrangian properties of the flows using the single particle dispersion, pair separation, Finite Time Lyaponov Exponent (FTLE) and topological braids [6].

In this talk, I will give a brief overview of the chaotic flow generation in the laboratory using Faraday waves. Analysis of the Lagrangian properties of the flow will be presented. At last, I will report analysis of topological braids, which reveals the existence of coherent bundles in two-dimensional turbulence [7]. The existence of such bundles, whose width is determined by the turbulence forcing scale, substantially modifies the statistics of pair dispersion in 2D turbulence as compared with the expectations from the Richardson-Obukhov law. The results point to a single scale dynamics of the pair separation and the importance of extreme separation events.

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Quantum-Size Effects in Thermoelectric Parameters of Nanostructures IV-VI

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The paper presents an analysis of new approaches to improve the thermoelectric parameters of nanostructures based compounds IV-VI.
Oscillation character of the thickness dependences of kinetic parameters quantum wells superlattices suggests that this behavior is due to quantum size effects associated with the restriction of movement of the main type carrier. Definition of oscillation period yielded the energy parameters of corresponding nanostructures.
Consideration of d-dependence of the Fermi energy EF and z-component of the effective mass allowed us to obtain the corresponding dependences of the Seebeck coefficient S and electrical conductivity σ on the well width for nanofilms of lead chalcogenides.

The calculation was carried out in the approximation of constant concentration and carrier mobility across all the range of well width. The values of the last were selected basing on the relevant experimental measurements. The resulting dependences of TE coefficients on the width of lead chalcogenides QW are characterized by nonmonotonic oscillating behavior, what is in a good coordination with the experimental results.

Innovations and Chaos in Economic Systems

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The prospects of development of world economy is now usually associated with formation of innovative economy. The innovation as a peculiar form of chaos can become a push and the mechanism of an exit to one of possible trajectories of development corresponding to internal tendencies of economic system and providing its new qualitative state. In it is the constructive role of innovative factors for start of processes of self-organization in system and preparation it to various scenarios of development consists. The innovation as kind of chaos is the factor bringing nonlinear systems to own structures attractors.
As innovations are a chaos element in relation to the existing economic system, their introduction causes the self-organization process directed on adaptation of a new element in structure in system. For adaptation acceleration, the system develops internal reciprocal innovations, interrelations between elements become complicated, and the structure of system changes. At the first stage of self-organization for ensuring stability of system the number of its reactions has to correspond to quantity of external signals. The system builds structure in which to each external influence, there corresponds the element capable to generate internal innovations and to influence change of structure of system.
At the following stage the economic system evolves in the direction of more and more ordered state. It is reached by means of hierarchy of elements: order parameters are established, the principle of submission joins, the effective group of the uniform internal innovations allowing to adapt with the smallest changes in structure of system, and, therefore, with the smallest expenses is provided. The system is in relative balance, and crucial importance is gained by the endogenous innovations promoting the fastest adaptation and self-organization.
The economic system selectively approaches response to exogenous innovations, setting the rigid mode for their penetration. She perceives only the influences answering to its nature, any other can negatively work, up to implementation of scenarios of chaos. Having reached a certain degree of internal force, nonlinear systems become more active,

structure external space according to the dynamic nature. Thus, property of innovation can be considered as violation of a habitual order of functioning of system. Contradictions, the conflicts and bankruptcies which accompany development of economic system can be connected with it. Similar processes can be softened, predicting the coming social and economic transformations or, on the contrary, to aggravate, consciously provoking the operated conflicts and chaotic processes. For the purpose of modeling of such scenarios the model of transition to innovative products is constructed and the analysis of chaotic processes which arise during introduction of innovations is made.
Keywords: Innovative economy, Innovations, Chaotic modeling, Model of innovative strategies, Chaotic simulation.

Homogenization method for the quadratic polynomial chaotic system

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This paper proposes a sufficient condition that determines the quadratic polynomial systems to be topologically conjugate to the Tent map. Base on this condition, the probability density function of a quadratic polynomial systems is easy to get, and the transformation which can homogenizes the novel chaotic system is also obtained. The performances of both the original system and the homogenized system have been evaluated. Numerical simulation examples show that the information entropy of the uniformly distributed sequences is closer to the theoretical limit, and its discrete entropy remains unchanged. This illustrates the effectiveness of the homogenization method which can not only keep all the chaotic characteristic of the system but also make it have better uniformity.
Keywords: chaotic system; homogenization; topologically conjugate; entropy.

Safety and risk analysis of an operational heater usin bayesian network

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Industrials systems, including chemical industries, can be exposed to undesirable events that may cause terrible accidents. These accidents

must be controlled and recuced. To this end, numerous risk analysis management approaches have been aimed at reducing the risk to a tolerable level to avoid the catastrophic accident.This reduction is achieved by implementing several layers of protection, including organizational and technical barriers, this later known as safety instrumented systems (SIS).The main objective assigned to a SIS is the detection of dangerous situations and implementation of a set of reactions necessary at a specific time to ensure that the equipment is under control.

Keywords: Bayesian network, Safety-instrumented system, Failure analysis

Interaction between a Single Soliton and an External Driving Wave Governed by Forced Benjamin-Ono Equation

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The wave field coupled with an external traveling wave is studied analytically and numerically from the viewpoint of Hamiltonian structure of the system. The field is defined by Benjamin-ono equation, which usually is used to describe inner solitary waves in the deep ocean and nonlinear waves in the incompressible boundary-layer. The interaction between the wave field and the external wave is reduced into a single soliton perturbed by an external force. The problem is still integrable under the approximation. The results show that the Hamiltonian structure is changed topologically with the strength coupling. Moreover, the change of number of fixed points is induced by Doppler shifted resonance between the soliton and the external driving wave. Indeed, the results can be applied to the generation of solitary waves in the deep ocean and incompressible boundary-layer.

Keywords: Soliton, Ocean flow, Boundary layer, Resonance, Hamiltonian structure.

Complex Dynamics In Hybrid Totalistic Cellular Automata Rule 3, 13 and 10

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In this article, the dynamical behaviors hybrid totalistic cellular automata (HTCAs) are researched from the viewpoint of symbolic dynamic. Elementary cellular automata (ECA) rule 3, 13 and 10 can generate a lot of gliders in the hybrid mechanism. After the classification and coding of the newly discovered gliders, we provide a method to analyze the chaotic dynamics properties of the glider by symbolic dynamics. It is proved that the glider can be expressed as a particular subsystem with complicated dynamical properties, such as topologically mixing and positive topological entropy, so that it is chaotic in the sense of both Li-Yorke and Devaney in corresponding subsystems.
Keywords: Totalistic cellular automata, hybrid mechanism, symbolic dynamics, glider, chaos, topologically mixing, topological entropy.

Fault Location in TDM-PON with High Spatial Resolution Utilizing the Delay Signature of Chaotic Laser

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We propose a method using the delay signature, which is regarded as a nuisance in many application of chaotic laser generated by optical feedback, to precise locate the fault in a time-division multiplexed-passive optical network (TDM-PON). In our experiment, a fiber Bragg grating is inserted in each branch of the TDM-PON to provide the optical feedback, which can lead the monitoring laser to generate chaos. And the fiber fault can provide the optical feedback as well. Therefore, a chaos generation with multi-feedback structure is constructed. The feedback position can be observed by the delay signature, which is hard to eliminate in chaos system generated by feedback. We use the FBGs as markers for the identification of each branch and locate the fault by its feedback. The experiment results show the identification of the faulty branch and the location of the fault point in an optical network simultaneously. This is achieved with a 6-km feeder fiber, and realizes the 8-mm spatial resolution.
Keywords: Delay signature, Fault location, TDM-PON, Chaotic laser.

Efficient Selective Image Encryption with Public Key based on DNA Coding and Chaotic Maps

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With the rapid development of network communications, security has become more and more important issue for image in the digital world. Cryptographic methods are required to guarantee sufficient security, integrity, confidentiality during image storage and transmission. In this paper, a novel and efficient selective image encryption (SIE) scheme has been proposed based on DNA coding and chaotic maps. The extreme sensitivity of chaotic system can greatly increase the complexity of the proposed scheme. Eight DNA coding rules are mixed to enhance the efficiency of image confusion and diffusion. Information entropy is modulated as the parameter of spatiotemporal chaotic system to resist the chosen-plaintext attack. Furthermore, an improved public key cryptosystem based on Chebyshev polynomials is proposed to solve the secret key distribution and information entropy transmission problem. Experimental simulation illustrates the feasibility of SIE scheme and performance analysis shows the security and validity to resistance the statistical and differential attacks.

Keywords: Selective Image Encryption, Chaotic System, DNA Coding, Public Key Cryptosystem, Chebyshev Polynomial.